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INDIANA.

DEPARTMENT

OF

Geology and Natural History

(FOURTEENTH ANNUAL REPORT.)

Part First, Geology and Natural History.
Part Second, Post-Pliocene Vertebrates of Indiana.
(By Prof. E. D. Cope and Jas. Wortman.)

JOHN COLLETT,
STATE GEOLOGIST.

1884.

TO THE GOVERNOR.

INDIANAPOLIS:
WM. B. BURFORD, STATIONER, PRINTER, LITHOGRAPHER AND BINDER.
1884.

STATE OF INDIANA,
OFFICE OF STATE GEOLOGIST,
November 2, 1884.

HON. ALBERT G. PORTER,

Governor of Indiana:

Herewith I transmit to Your Excellency the Fourteenth Annual Report of the State Geologist, being for the year 1884, embracing the labors of myself and assistants in the field, study and cabinet, with detailed survey of several of the most important counties of the State. To this is added a study of the Post-Pliocene Vertebrates of Indiana, by that distinguished comparative anatomist, Edward D. Cope.

JOHN COLLETT,
State Geologist.

STATE OF INDIANA,
EXECUTIVE DEPARTMENT.

Received November 8, 1884, examined by the Governor, and transmitted to the Secretary of State, to be filed and published according to law.

FRANK H. BLACKLEDGE,
Private Secretary.

Filed in my office this 11th day of November, A. D. 1884.

W. R. MYERS,
Secretary of State.

DEPARTMENT OF GEOLOGY AND NATURAL HISTORY,

INDIANAPOLIS, IND.

JOHN COLLETT, State Geologist.

PLEASE ACKNOWLEDGE RECEIPT OF THIS VOLUME.

In return, Scientific Books, Fossils, etc., and Implements of the "Stone Age" are acceptable.

State Museum and Office, corner of Market and Tennessee Streets.

ROSTER.

JOHN COLLETT, A. M., M. D., Ph. D.
Chief of Department, and State Geologist.

FIELD-WORK ASSISTANTS.

RYLAND T. BROWN, M. D., Indianapolis, Ind.
MOSES N. ELROD, M. D., Hartsville, Ind.
A. J. PHINNEY, M. D., Muncie, Ind.
Rev. D. S. McCASLIN, A. M., Pullman, Ill.

SPECIAL ASSISTANTS.

BOTANIST.
Prof. JOHN M. COULTER, A. M., Crawfordsville, Ind.

CHEMIST.
JOHN N. HURTY, M. D., Indianapolis, Ind.

COMPARATIVE ANATOMIST.
ALEMBERT W. BRAYTON, M. D., Indianapolis, Ind.

CONCHOLOGIST.
FRED. STEIN, M. D., Indianapolis, Ind.

ENTOMOLOGIST.
RALPH St. J. PERRY, M. D., Indianapolis, Ind.

ORNITHOLOGIST AND TAXIDERMIST.
FLETCHER M. NOE, Indianapolis, Ind.

HERPETOLOGIST AND ICHTHYOLOGIST.
Prof. OLIVER P. HAY, Irvington, Ind.

PALEONTOLOGISTS.
Prof. ED. D. COPE, Philadelphia.
Prof. JAS. L. WORTMAN, Philadelphia.

INTRODUCTION.

The rapid growth of Indiana in population, and its widespread and multiplying industries, stimulates research, and renders important every newly discovered feature in the mineral and agricultural resources of the State.

It is the object of the geologist in prosecuting his survey of the State, to make it as searching as possible, and turn to use every object that will serve to cheapen and foster these industries. Things that appear common and worthless in themselves when properly studied and brought into combination with one another in a suitable manner sometimes give rise to products of great utility, and furnish employment in a direction that provides a new field of operation, and draws from those industries where there is a superabundance of laborers seeking to be employed.

Chief among the industries of the State is agriculture, and this art has for its foundation the soil. The soil of Indiana in its virgin condition compares favorably with that of any Western State, and the portions in cultivation yield cereal and grass crops fully up to those of the most favored portions of the Union, but from the very nature of the origin of this soil, we find great irregularity of productiveness in almost every field; in farmers' parlance, the land is spotted. The siliceous and muddy sediments formed by the disintegration and grinding down of the rock-burdened regions that lay to the northward, by glaciation and its distribution by water, separated the material into mud more or less argillaceous, argo-siliceous, sandy and gravelly soils. Where the former character of soil prevails it is stiff, very retentive of water, and in its natural condition, no matter how much pains may be taken in the tillage to make it

produce even a moderate crop of any farm product. This may be taken as the worst form of ordinary dry land that the frugal farmer has to deal with, and we find it grading down through every variety of soil to that which may be termed purely "sandy." In passing over the country one can see in almost every field that has not been drained ashen-colored spots on which there has been a very sparse yield of grain or grass. They are to be seen on the highest as well as the lowest elevations, and when first cleared for farming purposes, in most cases, were the home of the craw-fish, whose chimney-capped holes gave proof of their presence. These crustaceans live in fresh water, and on inspection their holes will be found to lead down to permanent water, and this at no very great depth. No amount of fertilizing will render such land productive, and there is but one effective remedy, underdraining.

Other names given to such lands by farmers are "cold land" and "sour land." Plants can not fully mature when their roots are in a substratum of water. By capillary attraction and the influence of the sun, the water is brought to the surface and there evaporates. This evaporation robs the soil of its heat, which goes off in the vapor, and the name of "cold land" is therefore very properly applied to such soils. Under this process of evaporation at the surface, a circulation is kept up from below upwards, and the roots of the plants are not only chilled but they are deprived of a free circulation of warm air, which is as essential to the welfare of the plant as it is to the lungs of animals. It has been one of the main objects in the prosecution of the Geological Survey to make known the physical defects of the lands, and call attention to the importance of tile underdrains as the only sure means of remedying these serious drawbacks on successful culture, and we now find the people everywhere fully aroused on the subject, and innumerable unproductive fields have been underdrained, and the good effects resulting from it have been so apparent that manufactures of drain tile have been established in almost every county. Abundant clays suitable for making these tile can be had in all parts of the State, and the industry has become one of great magnitude, and gives employment to a large number of men and boys.

The improvement thus wrought to agriculture is not alone productive of large moneyed gains to the farmer, but the

thorough draining of the land has removed the cause of malarial diseases; the "ague belt of the Wabash" has been almost obliterated, and bilious fever, once so common in all parts of the State, is now seldom known within its borders. Indeed, I know of no outlay of money that has brought so beneficial a change in the prosperity and sanitary condition of the State.

COAL LANDS.

The productive coal lands of Indiana embrace about 250,000 acres. Before the inauguration of the Geological Survey this coal scarcely found a market except for smithing purposes. The supply for house purposes was mostly brought from the distant fields of Pennsylvania, where it was supposed, in popular parlance that good coal could alone be found; and the consumption of the latter coal was almost exclusively confined to cities and large towns.

The Geological Reports showed the abundance of coal in the State and its excellent quality. They were read, believed and quoted. In this way the resources of the State were advertised to the world and the attention of capitalists, miners and manufacturers was attracted. Before the Survey, the coal lands of this State were worth from $2 to $10 per acre. They now sell readily at from $50 to $200 per acre, while Indiana coal is used to a very large extent by railroads and manufacturing establishments, and for household purposes. Not only have its uses extended over our own State, but it finds a profitable market in our neighboring States, and extensive shipments are made as far west as the State of Kansas. The Reports issued showing the good quality of our coal have either suggested or aided the construction of four or five important railroads, and prepared the way for others.

Placing the average extent of counties included in the coal regions at 250,000 acres, the increased value of previously unproductive land would exceed $30,000,000, and adding the benefits derived from the setting up of forges, furnaces, factories and mills, and the building of railways, it is probably within the the mark to state that the aggregate increase in values resulting from the development of the coal fields has reached $100,000,000. This great benefit to the State has been brought about to a very great extent, if not altogether, by the labors of

the Geological Survey, and it should also be remembered in this connection that the money invested in operating our coal fields is largely foreign capital which has been brought within our reach for the purposes of taxation.

Such results alone represent more than a thousand per cent. profit on the cost of the Survey. But many of the equally suggestive facts remain to be stated. The increased shipments from the town of Brazil, in Clay county, represent annually more money than the entire cost of the Survey. Ten years ago a few carloads per annum constituted the entire export trade; and the same statement holds equally true in regard to the Washington mines, in Daviess county. The annual shipments are now from 250,000 to 300,000 tons, and the proprietors of mines are glad to arm themselves with analyses and letters from the State Geologist showing the purity and excellence of Indiana coal, by means of which they have built up an extensive shipping trade, while the cannel coal of Daviess county, by reason of its superiority as a grate fuel and for its illuminating qualities, now commands a full market in all directions outside of this State. The proprietors of coal mines are very frank to acknowledge the benefits derived from the Geological Survey.

There are 206 mines in nineteen counties of the State, employing 5,403 men, producing 2,500,000 tons of coal, requiring a capital of $1,600,000 for the present year.

THE BUILDING-STONE QUARRIES.

The Reports also show that Indiana has more than two hundred square miles of the best building stone to be found in any Western State, if not in the world. This stone has been found in great variety of color and grade, and the tests applied have shown it to be of such enduring strength as to create a large demand. In this way another channel has been opened for the investment of large sums of money by Eastern capitalists, and many quarries are now being operated by skilled workmen, with the aid of the most approved machinery and tools. The product of these quarries, which a few years ago did not exceed $30,000 per annum, will, during the present year, amount to a very large sum. The citizens of Owen, Monroe, Lawrence, Washington, Harrison and other counties, fully appreciate the assistance they have received from the Geological Survey, and

recognize that the prospect before them is that in the near future the increase of Indiana's wealth from her stone quarries will be equal to that resulting from the successful working of her coal mines.

OTHER RESOURCES.

If proper methods were adopted, nearly as good returns might be made from the sale of clays and other materials, which are at present almost unknown. The fine porcelain clay of Lawrence county, which was supposed at first to be confined to an area of about forty acres of profitable beds, is now found to extend over several hundred acres, and opens up a field for the introduction of the most extensive porcelain manufactories in the United States, since nowhere else is a clay found of such a pure white color and freedom from oxide of iron. Other States carefully test and report upon their medicinal springs and derive handsome revenues therefrom. The Indiana sulphur waters are equal, and in some respects superior, to any in the world. It would pay the State well to make them more widely known, as the effect would be to induce our own citizens to spend their money at home, and to bring extensive patronage from strangers for our railways, stage coaches, hotels, etc. Indiana could readily reap a profit of several hundred thousand dollars per annum from this source, besides furnishing great relief, if not positive cures, to invalids.

The Geological Reports which have been published from time to time have gone over the whole land, and their accuracy has scarcely been questioned. The highest scientific authorities of this country and Europe have commended them as meritorious; while scientific journals, magazines, and newspapers of the Eastern States, England, Germany, and France have copied extracts with commendation. It has been charged that these reports are advertisements. The results show that they have been good advertisements, and that it pays Indiana well to advertise in that way. The State has done well in the past by advertising her resources, and will do still better by continuing it in the future. Indiana must show her attractions—must thrust her invitations into the hands of outsiders to enlist them in her army of productive citizens. We have room for millions. Our mines and quarries are only opened. Our forests offer the

best of timber to the workers in wood. Our farm land is not half improved. We not only have room for immigrants, but we need their help.

It is to be hoped that the coming Legislature will make ample appropriation to conduct the Survey on a basis more commensurate with its great utility and benefits to the people. This appropriation should not be less than $8,000 annually, to be used as follows:

Salary State Geologist	$2,500 00
Expert curator of museum and Secretary	800 00
Increase of museum	500 00
Field work	2,000 00
Chemical and paleontological work	2,000 00
Stationary and postage, etc	200 00

It is eminently proper that I should call attention to this matter from the fact that the new State House will soon be completed and ready for use. In this magnificent structure, which reflects so much credit on the State, provisions are made for the geological department. There are rooms for the museum, which is rapidly being filled with the minerals and natural history objects of the State, and which is now so greatly in need of space for its rapid growth. There is also an appropriate room for a chemical laboratory, which is to geology what mathematics is to the astronomer—the "*experimentum crucis.*"

A comparison of the cost of Surveys in Indiana with those of other States will show that the work has been performed here at a minimum. The Ohio Geological and Paleontological Reports cost $3.47 a volume. The Indiana Report of 1881, the most expensive yet produced, cost eighty cents per copy, while Illinois Paleontology cost about $3.00 per volume. Indiana, at a former session of the Legislature, appropriated $5,000 annually for Geological Surveys. Georgia appropriates $10,000 annually, New York, $25,000, and Pennsylvania, $50,000.

Finally, the Survey has been a good educator. It enables every one to understand the geology of his county, the minerals he can or can not find; saves useless and expensive search, and sends forth men so posted that some of the most profitable enterprises in other States have been begun and conducted by those who were Hoosier boys.

Experience has shown in every country and State the importance of having a permanent office of Geology and Natural History, with a director in charge who is able to give strangers and people at home accurate and official information on all subjects relating to the rocks, clays, coals, and all other minerals, especially those within the limits of his jurisdiction, and general information regarding the geological and mineralogical resources of all other portions of the United States. Indeed, it becomes a bureau stored with important information, to be furnished gratuitously to all who seek for counsel and advice in matters within its range. Geology is a department in natural history that depends on investigation and developments for its progress. Evidences which tend to enrich science, that are not found to-day, may be found to-morrow, consequently the science is being daily promoted by new discoveries. The geological surveys of England, Scotland and Ireland have been in progress for at least fifty years, and still furnish new and important information to promote the welfare of the people. The same may be said of New York: while extensive field-work has been stopped, the venerable State Geologist, James Hall, from whose labors have evolved the fundamental nomenclature of geological epochs which serve as a basis for American geology, still holds the office of State Geologist, and finds plenty of work to do. Pennsylvania prosecuted an extensive survey under the able directorship of the late Henry D. Rogers, and then stopped, under the mistaken impression that his reports exhausted the subject. But it was soon discovered by wise statesmen that very much remained to be done, and the work was reinstated with J. Peter Lesley as director. He is aided by a large corps of assistants, and the work is being carried on with admirable detail and is alike creditable to science and the people of the State, whose welfare it has so greatly promoted. It is not for myself that I speak, when expressing the hope that the Legislature will see the wisdom of keeping alive the Geological Survey of Indiana, but for the people of the State, whose commercial welfare it has and will continue to promote.

WORK OF THE DEPARTMENT.

The State Geologist, in presenting his Third Annual Report [Fourteenth General Report] must say, that owing to the accidental failure of the General Appropriation Bill this Department, as well as others, has labored under difficulties. There has been no public fund for expenses whatever since May, 1883, as the special appropriation of $5,000 per annum ended at that time. The Chief of the Department without funds, was governed by *mandatory duties.* He was *directed by law* "to continue the Geological Survey of the State by counties or districts, to give attention to the discovery of minerals, stone or other natural substances useful in agriculture, manufactures and the mechanical arts," and "care for the Geological cabinet, museum, apparatus and library, and their increase."

These duties commanded by law, required the expenditure of cash. By extra labor of himself, ranging from ten to fourteen hours a day, he has reduced the expenses to a minimum—much below their worth—which he has paid out of his private funds, and will present an account, with vouchers, to the Legislature for re-payment. He expects citizens, who consider these Reports of 1880, 1881, 1882, 1883 and 1884 meritorious and of good influence for the industries and advancement of Indiana, to see their Senators and Representatives on the propriety of refunding the expenses, and making a permanent appropriation for this Department.

The cabinet has been increased considerably during the last year, but several thousand specimens can not, for want of space, be placed in the cases. Additions, also, have been made to the library by donations from the National Government, and from States and Scientists of the United States, and from Mexico,

Spain, Portugal, France, Holland, Belgium, Prussia, Austria, Bohemia, Italy, Norway, Sweden, Denmark, England, Scotland and Canada.

During the present year, 1884, detail Surveys have been made by Assistants, as follows: Fayette county and Union county, by Moses N. Elrod, of Hartsville, Indiana; Hamilton county and Madison county, by Ryland T. Brown, M. D., of Indianapolis. Hearty thanks are returned to these expert scientists for the zeal and energy exhibited by their reports. Their surveys have been conducted with remarkable care and fidelity.

The State Geologist has acted in that capacity, and as office assistant, secretary, workman and errand boy, occupying his time pretty fully during working hours. He has answered nearly three thousand letters and cards of inquiry, and given advice and opinions on various and many branches of economic science, sometimes involving the investment of large sums of money. He has also made reconnoissances in the southern and western part of the State. His time has been fully occupied, requiring much work, on his part, outside of business hours.

His term of office expires by law in April, 1885. He earnestly urges that such an office should be maintained and filled by a competent man, on whom citizens may call, without money or price, for information as to their mistakes or discoveries, and where those from abroad can obtain information of the wealth and resources of Indiana. This is believed to be more important to the State than additional *field work* or *Paleontological descriptions and discoveries.*

This office has, in the past, done much to advance the economic interests of the State. More can be done in the future.

By careful foresight on the part of the State Geologist, the last Reports were produced at a very low cost—less than $1 a volume. In other States such reports have cost from $2 to $15, averaging $4.80 a volume. The Department is proud of these reports, and the high favor and unqualified commendation they have received from scientists, not only at home and in our sister States, but also in Canada, England, Germany, Australia and other foreign countries. The demand for them has been sufficient to require a far larger number than the law limited the issue to. These reports, as well as those issued previously by this Department, embodying the careful and efficient work of my talented predecessors, are in great demand among scientists all over the

world, and are already regarded as valuable geological works, and have now become rare and difficult to obtain.

They are not alone contributions to the science of the age, but enable the students and teachers of the State to gain access to valuable scientific knowledge at a nominal cost, while the library of a scientist will often cost from $10,000 to $20,000. It is believed that the State should continue this course until not only her geology is accessible to her sons and daughters, but, adhering to her duty to humanity and the advancement of knowledge and civilization, such reports shall also embody the botany, conchology and each branch of the vertebrate life of the State.

The quota of Geological Reports for each county are distributed through the respective County Auditors to citizens and township and public libraries, and by County Superintendents to teachers. No reports are sent except on receipt of twenty to twenty-five cents in stamps—the expense of mailing.

The following shows the financial exhibit for the year ending October 31, 1883, but it must be observed that this Department has had no public funds for expenses since May, 1883, so that all work of assistants since that time has been paid by the State Geologist, in faith that future legislation will reimburse him.

The State Museum has constantly increased. Several thousand specimens are in boxes and cases not on the shelves, for want of funds to clean them. These will more than fill the cases when the present Chief removes the contents of the twenty cases which are his private property. J. C.

FINANCIAL STATEMENT FOR THE YEAR ENDING OCTOBER 31, 1884.

STATE OF INDIANA,
DEPARTMENT OF GEOLOGY AND NATURAL HISTORY,
INDIANAPOLIS, IND., October 31, 1884.

To His Excellency, Albert G. Porter, Governor of Indiana:

SIR: In accordance with custom, I submit the detailed statement of expenditures of this Department for the fiscal year ending October 31, 1884, with proper vouchers from No. 117 to 159 inclusive.

STATUTE APPROPRIATION.

Salary of State Geologist for October, 1883	$150 00
Salary of State Geologist for November, 1883	150 00
Salary of State Geologist for December, 1883	150 00
Salary of State Geologist for January, 1884	150 00
Salary of State Geologist for February, 1884	150 00
Salary of State Geologist for March, 1884	150 00
Salary of State Geologist for April, 1884	150 00
Salary of State Geologist for May, 1884	150 00
Salary of State Geologist for June, 1884	150 00
Salary of State Geologist for July, 1884	150 00
Salary of State Geologist for August, 1884	150 00
Salary of State Geologist for September, 1884	150 00
Total of statute appropriation for salary	$1,800 00

The foregoing statement corresponds with the books in my office.

JAS. H. RICE,
Auditor of State.

Necessary expenditures, vouchers 117 to 159, inclusive, paid by the State Geologist from his private funds:

No. V'chr.	1883.			
117	Feb.	27.	W. B. Burford, printing and stationery	$110 66
118	Mar.	2.	H. C. Chandler & Co., cut of fossils	5 40
119	June	10.	Samuel Morrison, correcting map	5 00
120	"	12.	O. B. Gilkey, signs for specimen cases	13 10
121	"	25.	Prof. Edward D. Cope, paleontological work and drawings	250 00
122	"	25.	Dr. J. S. Newberry, geological work	75 00
123	July	2.	Geo. K. Green, work in museum	71 10
124	"	31.	Geo. K. Green, work in museum	65 75
125	Aug.	16.	W. DeM. Hooper, proof reading and index	37 50
126	"	30.	Henry F. Suhr, packing reports	5 00
127	Sept.	3.	W. A. Speake, packing reports	9 45
128	"	6.	Sentinel Co., stationery	10 45
129	"	21.	W. B. Burford, wrapping and mailing reports	11 20
130	"	21.	Bowen, Stewart & Co., packing paper	10 83
131	Oct.	4.	S. Bernstein, mica for stoves	5 40
132	"	10.	W. A. Speake, packing reports	2 40
133	Dec.	1.	R. T. Brown, survey and report of Morgan county	75 00
134	"	28.	G. W. Puterbaugh, express on wood specimens	11 40

No. V'chr.	1884.			
135	Jan.	29.	M. N. Elrod, report of Rush county	50 00
136	Mar.	11.	G. M. Levette, compiling coal analyses	36 50
137	"	22.	John M. Godown, delin. and col. geological map	5 00
138	April	5.	G. M. Levette, section drawings geological map	12 00
139	May	28.	Leo Lesquereux, index to Paleontological Botany	5 00
140	"	30.	Geo. H. Fleming, proof reading geological report	12 00
141	June	6.	O. F. Mayhew, clerk	15 00
142	July	2.	Jno. R. Gibson, clerk	8 68
143	"	21.	Carter and Pouder, chemicals	5 35
144	"	22.	Dr. M. N. Elrod, extra work on geological survey	10 00
145	"	25.	Geo. H. Fleming, proof reading geological report.	20 00
146	"	26.	Jno. R. Gibson, work on Geological Report	5 77
147	Aug.	2.	" " " "	9 00
148	"	9.	" " " "	7 50
149	"	16.	" " " "	5 65
150	"	20.	Geo. H. Fleming, " " "	25 00
151	"	23.	Jno. R. Gibson, " " "	5 00
152	"	28.	W. B. Burford, printing and stationery	56 95
153	"	30.	Jno. R. Gibson, clerk	7 87
154	Sept.	6.	" "	10 00
155	Oct.	4.	Dr. R. T. Brown, survey and report of Hamilton and Madison counties	85 00
156	"	11.	Jno. R. Gibson, work on Geological Report	16 50
157	"	24.	Geo. H. Fleming, work on Geological Report	5 00
158	"	31.	Dr. M. N. Elrod, survey and report of Union and Fayette counties.	85 00
159	"	31.	John Collett, office expenses from April 1, 1883 to October 31, 1884, inclusive	216 35
	Total			$1,494 76

RECAPITULATION.

Statute appropriation	$1,800 00
Necessary expenses.	1,494 76
Grand total	$3,294 76

It will be seen that the last account, $1,494.76, includes not only the expenses of Department for the fiscal year ending October 31, 1884, but as well the running expenses for the months of June, July, August, September and October, of the last fiscal year, or for a period of nearly eighteen months; for the appropriation made for this Department four years ago expired in April, 1883. With mandatory duties commanded by law, the Geologist has carried on the work at less than an honest minimum, and relies on the justice of Indiana to reimburse him in the sum of $1,494.76, and for running expenses since October 31, 1884. Respectfully submitted,

JOHN COLLETT,

NOVEMBER 2, 1884. *State Geologist.*

GEOLOGY OF INDIANA.

GEOLOGICAL MAP.*

The accompanying geological map of Indiana gives a fair exhibit of the surface geology of the State. It is a compilation of all the labors of my distinguished predecessors and their assistants, as Owen, Lawrence, Brown, Cox, etc., etc., also of myself and assistants. To all workers in the State and amateurs the fullest credit and acknowledgments are given.

Much of the geology of the northern and northwestern areas is given, not accessible before the surveys of Newton and Jasper counties. The map comprises over one hundred years of labor and study of these devotees to science, as well as the results of thousands of miles of travel with pick and hammer.

In every dividing line between formations, outliers will be found to the east and north on the hill tops; to the west and south denuded areas of lower strata will be found.

The map is the best that can be prepared on so small a scale now; in the future, with better facilities and on a sectional scale, more finished work may be expected. It is believed that it will be appreciated by our citizens as a chart giving years of study and labor, condensed in a single sheet, and invaluable to teacher, student and citizen.

The sections on the borders of the map exhibit a large amount of labor and observation. The vertical sections are an average of studies along each line of outcrop and the deep bores in all divisions of the State. The horizontal section, from Vincennes to Lawrenceburg, shows the railway lines of the Ohio and Mississippi road, the surface rocks, etc. The dip is at the conventional rate of 30°, as the dip of each stratum is rapid near the rim of each basin—from 40 to 100 feet to the mile—but afterward ranges at 10 to 20 feet to the mile.

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* Revised and corrected from Vol. XIII for this Report.

OUTLINE GEOLOGY OF INDIANA.*

LOWER SILURIAN.

The rocks of the Lower Silurian age, known as the Hudson River or Cincinnati group, are found in the southeastern division of the State, extending also throughout large areas in Ohio and Kentucky. They are well exposed in the bluffs of the Ohio River, extending west to the mouth of Fourteen-mile Creek, in Clark county, and form the surface rocks in the counties of Wayne, Union, part of Fayette, Franklin, Dearborn, Ohio, Ripley and Switzerland. In several of the adjoining counties to the west are exposures of Lower Silurian in ravines and deep cuts, as on the extreme east side of Clark, Jefferson, Decatur and Rush. The rocks of this formation are filled with well-preserved fossils, and, by decomposition, form a rich and highly productive soil.

UPPER SILURIAN.

Strata of the Upper Silurian formation form the general surface rocks of the counties immediately west and northwest of those in the Lower Silurian, including Adams, Wells, Huntington, Wabash, Miami, part of Jasper, White, Cass, part of Carroll, Jay, Blackford, Grant, part of Howard, Delaware, Madison, Tipton and Hamilton, Randolph, Henry, Hancock, Rush, Shelby, Decatur, the eastern part of Marion, Bartholomew, Jennings, Jefferson, and the eastern part of Clark county. The Upper Silurian strata also extend north and northwest from these counties to the northern boundary of the State, at many points being capped by uneroded areas of Devonian age, but so deeply covered with bowlder drift as to be rarely seen, and its presence is more known by test bores than by outcrops in the drift district.

Soils derived from the disintegration of rocks of this age are, as a rule, cold, heavy clays, which, when drained, produce good crops of wheat and the grasses.

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*Repeated from many requests, as each year they fall to new hands who do not possess former Reports.—COLLETT.

DEVONIAN.

The Devonian rocks are exposed in a narrow band, commencing, on the south, at the Ohio River in Clark and Floyd counties, and extend, thence, north and west through the counties of Scott, Jackson, Bartholomew, Johnson, Marion, Boone, Clinton and Carroll, with local exposures in Tippecanoe, Cass, White and Jasper, Miami, Wabash, parts of Shelby, Jennings, Jefferson and Jackson. From fossils collected in the drift area, to the north and west and from test bores, it is known that Devonian rocks have been more or less eroded, but once covered much of the northern third of the State, and at many points they are still in place.

LOWER CARBONIFEROUS OR MOUNTAIN LIMESTONE.

Rocks of the Lower Carboniferous series form the surface strata in a wide belt west of the Devonian and east of the Coal Measures, and these, for the most part, constitute the rocky exposures of the counties of Harrison, Crawford, Orange, Washington, Lawrence, Brown, Monroe, Owen, Morgan, Putnam, Hendricks, Montgomery, Tippecanoe and Benton, with parts of Perry, Floyd and Jackson. The eastern line of this belt is composed of shales and sandstones of the Knobstone group, while adjoining on the west are the great cavernous limestones of the State, so well exhibited in the southern counties, but which thin out to a few feet at the north. The soil of this district is remarkable for its growth of cereals and grasses.

COAL MEASURES.

The rocks of the Coal Measures are found in the counties of Posey, Vanderburg, Warrick and Spencer, the western parts of Perry and Crawford, in Gibson, Pike, Dubois, Knox, Daviess, Martin, Sullivan, Greene and Clay, the western part of Owen, and in Vigo, Parke, Vermillion, Fountain and Warren, with a projection in a narrow band of Coal Measure rocks (Conglomerate sandstone), underlaid by thin beds of Keokuk limestone and Knobstone shales of the Lower Carboniferous group, extending from the northern part of Warren county, in a northeasterly direction across Benton, and terminating near Rensselaer, in Jasper county, where the Conglomerate is massive. It is probable that this projection is not continuous, but interrupted at intervals.

It is apparent, therefore, that the Lower Silurian, being the oldest rocks brought to the surface, underlie all of the more recent rocks which in succession have been deposited upon or about it during the different ages of the earth's existence. A shaft or bore put down in the western part of Gibson county would pierce, in succession, all the geological formations of the State, and would show the approximate depth of each.

GEOLOGICAL AND TOPOGRAPHICAL SURVEY

OF

HAMILTON AND MADISON COUNTIES,

INDIANA.

BY RYLAND T. BROWN, A. M., M. D.

1884.

HAMILTON COUNTY.

In giving names to the counties of Indiana the Legislature has generally aimed to perpetuate the memory of some illustrious patriot, hero, statesman, or scholar. In following this rule seventy-eight of the ninety-two counties of the State are so named. Hamilton county was named in honor of Alexander Hamilton, the statesman and financier who led the infant government of the United States out of the mire of an almost hopeless indebtedness. It was organized by an act of the Legislature in the month of January, 1823. The county is an exact square, being twenty miles long on each of its four boundary lines, and consequently embraces an area of four hundred square miles. It is bounded on the north by Tipton county, on the east by Madison, on the south by Marion and Hancock, and on the west by Boone and Clinton counties. It includes nine Congressional townships—three each numbered 18, 19 and 20 N. in ranges 3, 4 and 5 E., and two tiers of sections on the east from each township, in range 6; and a like number of sections on the south from each range in township 17. For civil purposes Hamilton county is divided into nine townships, lying in three tiers, named from west to east as follows: northern tier—Adams, Jackson and White River; middle tier—Washington, Noblesville and Wayne; southern tier—Clay, Delaware and Fall Creek. Of these Washington is the largest, embracing fifty-six square miles, and Clay the smallest, covering only thirty square miles.

HISTORY.

The territory embraced in Hamilton county was originally the home and hunting-ground of the Delaware tribe of Indians, and was ceded to the United States by the treaty of St. Mary's, October, 1818. One of the principal villages of that tribe was located on the south side of White River, a short distance above the great bend, in section 3, township 19, range 5. It was known by the early white traders as Strawtown, its Indian name is lost. In the war of 1812 it was occupied for some time by a squadron of Kentucky cavalry, which was placed there for the defense of the old men, women and children, while the warriors were serving as scouts and guides in General Harrison's army.

After the war of 1812 had closed, the two Conners, John and William, settled on White River as Indian traders. William Conner's first location was on the east side of the river near what is now the Marion county line, but this he soon abandoned for a more eligible situation about four miles below the present site of Noblesville. This was the point known as "Conner's Trading Post." John Conner formerly kept a trading post at Connersville, of which town he was the proprietor, but subsequently located on the west side of White River, a little below the mouth of Cicero Creek, where he built the first water mill in the "New Purchase." This mill has so completely disappeared that its location can hardly be identified. His son, William Conner, subsequently built a mill at the stone rapids, five miles above Noblesville, which remains to the present time, a valuable piece of machinery, and is kept in good order. It is the only mill on White River between the Madison county line and Martinsville, in Morgan county. In the spring of 1819 the three Finch brothers, John, Solomon and Isaac, with their families, settled on the horse-shoe prairie, two miles below Noblesville. These were soon after joined by William Bush and Thaddeus Baxter, together with their families. These constituted the first permanent white settlement, for cultivating the soil, made in the county. In the year 1821 a school was taught in this settlement by Miss Sarah Finch. In the year 1820, General John D. Stephenson, Judge Colborn and some others settled on the present site of Noblesville.

Under an act of the Legislature, Hamilton county was organized in January, 1823, by the appointment of John D. Stephenson, clerk, and William P. Warwick, sheriff, of the county, by whom an election was ordered for the other county officers. The county seat had not yet been established, and the first court was held in the autumn of that year at the residence of Wm. Conner, at which Hon. W. W. Wick presided and John Finch and Wm. C. Blackmore were the associate judges, then demanded by the statute of the State. At this term of the court, which was in session but two days, Daniel B. Wick, acting as prosecuting attorney, organized the first grand jury of the county.

The increase of population in Hamilton county has been very uniform. In 1830, the census shows a population of 1,787; in 1840 it is 9,855; in 1850, 12,684; in 1860, 17,310; in 1870, 20,882, and in 1880 there was a population numbering 24,801. A very large per cent. of this population is engaged in farming, and but 324 out of 24,801 are of foreign birth. This is a smaller per cent. of foreign population than is shown in any other county of the State, except Orange. It is but 1.3 per cent. of the whole population. Noblesville, which was established as the county seat late in the year 1823, had, in 1880, a population of 2,221. It has a handsome and substantial court house, several respectable church edifices, and a commodious school building. The private residences are generally neat and substantial, and some of them elegant structures; and the business houses are respectable, both in size and display of merchandise. The county sustains two weekly newspapers, published here, the Republican Ledger and the Independent. Besides the county seat, there are sixteen smaller towns distributed over the county, the largest of which are Cicero, Arcadia and Westfield.

Hamilton county has three railroads, the oldest of which is the Indianapolis, Peru & Chicago R. R., now operated jointly by the Wabash, St. Louis & Pacific and the Chicago, St. Louis & Pittsburgh railroads. A local road is now running trains from Noblesville to Anderson, and the Indianapolis division of the Louisville, New Albany & Chicago traverses the southwestern part of the county.

There are no large manufacturing establishments in the county, and the farms are generally of medium size and principally devoted to grain farming, which has proved fairly profitable, as the air of thrift everywhere amply testifies.

TOPOGRAPHY AND DRAINAGE.

Hamilton county occupies a position near the summit of drainage between the streams that flow directly into the Wabash and those that are tributary to it through White River, and is, therefore, one of the level counties of the State. While this is true of the county generally, there are portions of it that present a quite undulating surface. This is especially true of that section of it lying directly east of Noblesville and drained by Stony Creek. While the ascent is nowhere abrupt, yet the ridges sometimes reach an elevation of 150 feet above the bed of White River. This region of rolling land extends north to White River, but south, between Stony Creek and Fall Creek there is a considerable plain of level summit land. The northern tier of townships are chiefly level, the streams running in superficial channels. The western part of the county, south of the centre, is more broken, having frequent ridges or mound-like elevations, which, on examination, prove to be deposits of gravel from glacial action, and are of great value in the construction of roads.

The drainage of Hamilton county is effected through White River and its tributaries. From a point in section 33, town 20, range 5, White River flows in a general southwesterly course to its mouth; but from its source in Randolph county to this point its general course is nearly due west. It enters the county from the east, five miles from the northeast corner, and leaves it, crossing the southern line nine miles from the southwest corner of the county. In its whole course through the county, the river is skirted on one side or the other by large plains of second bottom or terrace land, and frequently there are large scopes of first bottom, which, however, are often subject to overflow in time of freshets. The principal tributaries of White River, whose mouths are in this county, are Stony Creek, from the east, and Cox's Creek, Cicero Creek and Duck Creek, from the west and north. The southeast corner of the county is drained by Fall Creek and its tributaries, Mud Creek and Sand Creek; and the drainage of the southwest corner of the county is effected through Eagle Creek and Williams' Creek. All these are tributaries of White River, having their mouths in Marion county. Stony Creek rises in Madison county, and flowing in a southwesterly direction it joins White River one mile south of Noblesville. It has generally a brisk current and, by its numerous tributaries, it drains a region of excellent farming land, which was originally heavily timbered with sugar tree, beech, ash, white oak, black walnut and yellow poplar. In the vicinity of White River, near the Madison county line, there is a region covered with a valuable growth of white oak timber, but the Noblesville & Anderson railroad has brought it within the reach of market and it is rapidly disappearing. The soil in this Stony Creek country is a rich vegetable loam, lying on a compact clay subsoil, forming a region of excellent farming land. Near the head of some of the northern branches of Stony Creek, there were originally a few small wet prairies, but they are now drained and in cultivation. South of this section, the land drained by the tributaries of Fall Creek is more level, and much of it is the "black land," covered with burr oak, elm and hickory timber. On this land the improvements are not so far advanced as on the drier soil, but drainage will ultimately make of this an excellent farming country.

Duck Creek rises in the northwest part of Madison county and running about nine miles through the northeastern part of Hamilton county, it enters White River near the great bend. In its upper course it is a surface stream and rather sluggish, but as it nears its mouth its channel is sunk deeper and its current becomes more rapid. It drains a section of very rich soil, but most of it will require both open ditches and subsoil tiling to render it fit for profitable farming. This it is receiving quite rapidly, converting a region of marshes into farms which in productiveness are not excelled by the best bottom land. Cicero Creek, which furnishes the drainage for one hundred and fifty square miles of the northwestern part of Hamilton

county, is a peculiar stream, not merely on account of its classical name, but for its individual characteristics as well. The legend of its name runs in this wise: The naming of the smaller streams was a part of the duty of the surveyor of the public lands. In the year 1820, Dr. William B. Laughlin was employed in the lineal survey of township 19, range 4, the lines of which frequently crossed this creek. Now, Dr. Laughlin was an educated Scotchman—a literary and medical graduate of the University of Edinburg, and almost insanely fond of the classics; but like many other fine scholars, he was not a notable success in his profession and was now in the employ of the Government as a surveyor. His oldest son, whose name was Cicero, was attached to his company of surveyors. A heavy rain had swelled the streams and made it difficult to cross them. The backwoods expedient for making a foot bridge by felling a tree across the creek was resorted to, and Cicero Laughlin, in crossing, missed his footing and fell in. He was with difficulty rescued in a nearly drowned condition. From this incident Dr. Laughlin called the stream Cicero's Creek; but in process of time the sign of the possessive case, or as the doctor would say the genitive, was dropped and the stream is now known as Cicero Creek.

But the topographical peculiarities of this stream are the relatively small size of the channel, compared with the great breadth of territory drained by it, and its remarkably curved general course. It rises in what was originally a wet prairie, which is now well drained, located near the northwest corner of the county. From thence it takes a generally northeast course through sloughs and marshes (now converted into public ditches), till it arrives at a point near the town of Tipton, the county seat of Tipton county. Here it makes an abrupt curve to the right and pursuing a southerly course, it re-enters Hamilton county a little east of Buena Vista, and continuing this general direction it forms a junction with White River about a mile below Noblesville. The principal tributaries of Cicero Creek are Hinkle Creek and Little Cicero. Hinkle Creek is chiefly notable for its heavy drift deposit and numerous gravel hills. This feature is especially noticeable near its source in sections 12, 13 and 21, in township 19, range 3, and in sections 7 and 18, in range 4 and the same township. These gravel hills sometimes rise to the height of fifty or seventy-five feet and the enclosed valley was originally a broad lagoon or swampy jungle. One of these occupying more than a square mile of territory, was known among the earlier settlers as "The Big Dismal." These marshes are now nearly all drained and in cultivation, and their luxuriant crops with the surrounding cordon of gravel hills make a romantic farm scene. The gravel knolls are themselves very productive, having three or four feet of sandy loam covering the imbedded gravel. In section 13 above named, on the farm of Milton Tomlinson, there occurs a large chalybeate spring which has made a considerable deposit of bog iron ore. The spring itself, as is generally the case with these chalybeate fountains, is a natural artesian

well, being a flow of water from beneath the lower blue clay through a natural fissure. Most of the wet prairies and bogs of this region are produced in this manner, as is demonstrated when ditches are cut through them. This theory is confirmed by several borings recently made through this clay in vicinity of Westfield, all of which produced flowing fountains. This is but three miles south of the Dismal. Hinkle, in the greater part of its length, drains a country of deep drift with an undulating surface of very productive soil.

Little Cicero Creek, like the parent stream, is noted for its great length and the remarkable curve that it sweeps. It rises in several public ditches in the vicinity of Sheridan and flows through a very level country in a northeasterly direction. For a distance of four miles, or nearly to Boxley, it flows between the banks of an artificial ditch, and all its tributaries are ditches. Several of these are fed by copious springs of chalybeate water, rising perpendicularly through the bed of compact blue clay underlying the slough which the ditch drains. Two of the largest of these are on the farm of Mr. John Underwood, half a mile northeast of Sheridan. They are strongly impregnated with iron and contain also magnesia and soda. For dyspepsia and other forms of impaired digestion and diseases of general debility, these springs will have valuable medicinal qualities.

This remarkable curve which Little Cicero Creek makes is accounted for by the range of gravel hills on Hinkle Creek, extending down to the town line at Westfield and westward to the elevated land drained by Eagle Creek; thus cutting off the direct drainage of the northwestern part of the county towards White River, and compelling it to make the circuit of these gravel hills, through the depression on the northern margin of the county, which is really a broad valley of erosion from which the material of the gravel hills of Hinkle Creek has been scooped out by glacial agency.

The northern half of township 18 and the southern half of township 19, range 3, are drained by Eagle Creek, and maintain the general character of heavy drift deposit which marks the land in the vicinity of that stream in its course through Marion county below. The same may be said of the country drained by Williams' Creek and the other small streams, immediately tributary to White River, which drain the southwestern corner of the county. None of the streams in this region have cut through the drift, nor have any borings here reached the rock in place, but the general configuration of the country indicates a great depth of drift in the southwestern quarter of the county.

The alluvium, or first bottom lands along White River are not so wide as they are below on this stream, yet many fine stretches of bottom from one-fourth to one-half a mile wide, extending for two or three miles along the river are found in several places. Many of these are subject to overflow in time of spring freshets, yet they are generally cultivated with a

fair degree of safety, and yield heavy crops, especially of corn, for the overflow being backwater, leaves a deposit that renders them very fertile. A few fine sections of terrace or second bottom land, were observed, though they are neither so large nor so well defined as they are below the Marion county line. That on which Noblesville stands is perhaps, the largest and best defined piece of second bottom in the county.

Hamilton county has a soil of good natural fertility, and nearly every acre in the county can be plowed. When the system of drainage now in progress is completed, no county in the State will excel Hamilton in productiveness, and but few will be more healthy. The supply of water, of a fair degree of purity is abundant everywhere, though springs of a good quality of water and durable, are not very common, but water, in a bed of gravel beneath twenty feet or more of clay, can be obtained almost everywhere, in quantities sufficient for domestic use and stock-water. I have already spoken of the flowing wells at Westfield. It is probable that borings reaching below the blue clay will give flowing wells in many places throughout the western section of the county.

GEOLOGY.

The line between the Silurian and Devonian formations crosses the northeastern part of this county, cutting off some thirty or forty square miles, under which lie Upper Silurian rocks belonging to the Niagara group. West of this is a belt of Pendleton sandstone outcropping from four to six miles wide. The remainder of the county lies on the Corniferous limestone, one of the lower members of the Devonian formation. This has a surface exposure only in a few places, being generally concealed under a heavy drift deposit. The Niagara limestone shows itself in the bed and bluffs of White River at intervals for three miles below the county line. It is rather a lead colored shale than a well formed rock, though some strata appear quite hard in the quarry; but clay stone, colored with proto-sulphide of iron, entering largely into its composition, is entirely unreliable for any building purposes, except furnaces and fire-places. Exposed to the air, it directly crumbles down and becomes a mass of blue clay. But if immediately from the quarry it is exposed to a high heat it assumes a red color, and becomes hard and quite durable. It may not be amiss, here, to say to persons selecting building stone that a blue colored stone, that is not crystalline in its structure is never reliable, however hard it may be. The Niagara limestone furnishes no trustworthy building material in this county.

The Pendleton sandstone, under which the Niagara dips to the west, has some strange features. Its geological relations and fossiliferous and lithological character will have a more particular notice in the description of its outcrop at Pendleton, in the report of Madison county, elsewhere

in this volume. This stone appears occasionally along Stony Creek for a distance of five miles below the county line. In most places the lower members of the overlying Corniferous limestone are exposed directly above the sandstone. Seeing that this sandstone is seldom more than twenty feet thick, its surface outcrop for a distance of five miles can be accounted for only by the fact that the direction of Stony Creek is nearly that of the dip of the rock, and the descent per mile about the same as the dip. In section 26, township 19, range 5, a quarry of this sandstone was opened in 1836, for the purpose of procuring stone to build a lock at Noblesville, on the Central Canal, then in progress of construction as part of our great internal improvement system. Nearly one hundred wagon loads of this peculiar sandstone were taken out of this quarry, and several blocks which were rejected, as unfit for dressing, are lying at the quarry. The exposure of forty-eight years has made no impression on them, thus attesting the durability of this rock. The strata at this point present a varying thickness, from ten inches to two feet. The overlying Corniferous limestone is thinly stratified.

This Pendleton sandstone appears in the bed of White River half a mile above Strawtown, but no quarry of it has been opened to determine its value. Near the mouth of Duck Creek, north of White River, the Corniferous limestone shows itself in the bed and banks of that creek, and stone for walling wells, and such neighborhood uses, has been taken out in several places, but no quarries have been regularly opened by which the value of this rock can be determined with certainty.

At Conner's Mill, five miles above Noblesville, stone shows itself in the bed of the river and forms distinct rapids in the stream. The exposed rock appears to be the transition from the Pendleton sandstone to the Corniferous limestone. No attempt has been made to utilize this rock for any purpose. The outcrops of rock in Hamilton county are quite barren of fossils. The Niagara shales have yielded nothing in their imperfect exposures in the upper sections of White River. A few fragmentary trilobites were observed imbedded in the debris of the Pendleton sandstone lying around the old quarry on Stony Creek, but all were too imperfect to determine the species. A few fragments of crinoid stems were detected in the Corniferous limestone near the mouth of Duck Creek.

ROAD MATERIAL.

Deposits of gravel, suitable for making roads, are abundant in the southern half of the county, and in certain localities in the northern section, beds of excellent gravel for road making may be obtained with but little search. This is especially true of the region around Deming (in township 19, range 4). A fine range of gravel hills extends north from Sheridan, along the county line. In many places in the northern part of

the county, beds of sand will be found replacing the gravel beds of the southern section. This is sometimes used as a substitute for gravel, and though inferior to the coarser material, it is a great improvement on a "mud road." It may not be out of place here to say that if a road-bed be well tile drained the amount of gravel necessary to make a good road will be greatly reduced.

ARCHÆOLOGY.

The only point of interest to the antiquarian in Hamilton county, is Strawtown and its vicinity. It is situated in section 3, town 19, N. range 5 E., and is in the concave of the great bend of White River. At, and above this point, that stream formed the line between the hunting ground of the Delaware Indians south of it, and the Miamis north. West of the great bend of White River the boundary was an undefined line extending west to the vicinity of Thorntown, thence running south to the territories of the Piankashaws, Wyandottes and Shawnees. Strawtown was for years the principal northern village of the Delawares, and home of their war chief. It is said to have been the most populous of the Delaware towns, in the first decade of the present century; this is confirmed by the large district of bottom land cultivated by the squaws when the whites first visited this locality, as well as by the extensive burying ground, on which the river is now encroaching, and exposing the bones of the red men at every freshet. The state of hostility which existed between the Delawares and the Miamis previous to the battle of Tippecanoe in 1811, elsewhere alluded to, growing out of the assumed right of the Delawares to sell certain districts of their lands to the whites without the consent of the confederated tribes, rendered Strawtown an insecure abode on account of the frequent incursions of the more warlike Miamis, who were their immediate neighbors. On this account Governor Harrison garrisoned Strawtown in the fall and winter of 1811 by a squadron of mounted riflemen, and in the spring of 1812 assisted in removing the old men, the women and children to their old home in Delaware county, Ohio, he having enlisted the warriors as scouts and guides in his campaign on the Maumee.

But Strawtown has an antiquity evidently higher than the days of the Delaware Indians. The mound builders have left their foot-prints in this vicinity by the numerous relics of the Stone age that have been picked up by the present inhabitants. A little west of the present village there is a burial mound about six feet high; it has been plowed over for a number of years, so that not only its height has been reduced, but its base rendered so indistinct that its diameter can not be accurately measured; it is, however, between seventy and eighty feet. It was opened in 1882

by Judge Overman, of Tipton, and four skeletons were found lying on the original surface of the ground, with their heads together and their feet directed to the cardinal points of the compass.

At a distance of 150 yards southeast of this mound is a circular embankment, now about three feet high, and twelve feet on the base. It has a ditch on the outside, which evidently furnished a portion of the earth for the embankment. The diameter of the circle, measured from the bottom of the ditch on each side, is 315 feet. There is a doubt as to what period this work should be referred. A tradition among the "old settlers" claims that the remains of palisades that once formed a stockade, were standing on the embankment when the early immigrants settled here. This tradition is strengthened by the fact that in 1810 a stockade was built by the Delaware Indians somewhere near this spot, as a protection against their Miami neighbors north of White River. Moreover, it was not the custom of the mound builders to make a ditch on the outside of their embankments. On the other hand, the regularity of the work, and the perfect form of the circle, is hardly compatible with the idea that this is the work of modern savages. It is possible that the circle dates back to the period of the mound builders, and that the Delawares took advantage of it to build their stockade on, and made the ditch to strengthen their palisades. The ditch has been filled, and the embankment reduced much by cultivation.

MISCELLANEOUS NOTES.

With the exception of a few small prairies, already alluded to, the whole surface of this county was originally covered with a dense forest much of which was valuable timber. But the necessity of removing it to prepare the ground for cultivation resulted in the destruction of vast quantities that would now be more valuable than the land on which it grew. In the south half of the county the valuable timber consisted chiefly of black walnut, white oak, wild cherry, and the different species of ash. Of these the trees were remarkable for their great size and height. On the black summit land of the northern townships the valuable timber was chiefly burr oak, of which the trees were numerous and large. A heavy growth of water elm (*Ulmus Americana*) covered this whole region and was originally considered a waste product of the soil, but recently it has become valuable in the manufacture of flour barrels. One tree of this species, which is the monarch of the forest, stands in the Fair Ground at Arcadia. It measures, three feet from the ground, twenty-three feet six inches in circumference, and is one hundred and fifteen feet high, with eighty feet spread of top.

MADISON COUNTY.

This county, like most of those in northern Indiana, is a regular parallelogram, but is peculiar in the fact that it is twice as long as it is wide, being thirty miles long from north to south, and but fifteen miles wide from east to west. It consequently covers an area of four hundred and fifty square miles. It is bounded on the north by Grant county, on the east by Delaware and Henry, on the south by Hancock, and on the west by Hamilton and Tipton counties. It embraces four whole Congressional townships and fourteen fractional townships. For civil purposes Madison county is divided into fourteen townships, arranged in five irregular tiers from east to west. Beginning at the north we have

First tier—Duck Creek, Boone and Van Buren.

Second tier—Pipe Creek and Monroe.

Third tier—Jackson, Lafayette and Richland.

Fourth tier—Stony Creek, Anderson and Union.

Fifth tier—Greene, Fall Creek and Adams.

Of these Monroe is the largest and Union the smallest. Anderson City, the county seat, is located on the south bank of White River, three miles south and two miles east of the centre of the county. It occupies the site of an Indian village which was destroyed in the war of 1812. It is beautifully situated on an undulating plain or series of low hills rising irregularly from the river to the general upland level of the country. In 1880 it had a population of 3,126.

The county is just now finishing a commodious, elegant and substantial court-house, and the city can claim a good supply of public buildings for school and church purposes. Summitville in Van Buren township, Alexandria in Monroe, Elwood and Frankton in Pipe Creek, Hamilton and Perkinsville in Jackson, Fishersburg in Stony Creek, Chesterfield in Union, New Columbus and Markleville in Adams, Huntsville and Pendleton in Fall Creek, and Alfont in Greene township, are all of them respectable country villages, and several of them towns of considerable size and importance. The section north of White River, being level and somewhat swampy, settled slowly. In 1834 there were but sixty-four polls assessed north of White River, but the construction of the Bee Line, the Pan-Handle, the Cincinnati, Wabash & Michigan, and the Muncie, Lafayette & St. Louis railroads through the county has rapidly increased the population.

EARLY HISTORY.

Madison is one of the "New Purchase" counties on which the Indian title was extinguished by the treaty of St. Mary's, in October, 1818, but lying north of the line of travel from the older settlements on White-Water, it gained population slower than did the counties south of this. It was

organized as a separate county in 1823, having been previously attached to Marion for judicial purposes. The first court in Madison county was held at Pendleton, which was the temporary county seat. It was convened in November, 1823, Hon. W. W. Wick presiding judge, and Adam Winsel and Samuel Holliday associates, and Calvin Fletcher circuit prosecutor. At this early day the principal settlement in the county was in the vicinity of Pendleton, and on this account it was made the temporary seat of justice, though no buildings were erected for the accommodation of the courts, these being held in private houses; Moses Cox, clerk, and Samuel Corry, sheriff, keeping their offices in their private log cabins.

Early in the spring of 1824, a crime of atrocious cruelty, and of sufficient importance to demand the interference of the general government, occurred in this county. The Delaware Indians had been removed beyond the Mississippi in the spring of 1821, and white immigration coming in slowly the wild game had increased rapidly. This induced a band of Seneca Indians, from their reservation in Ohio, to come into this region temporarily for the purpose of hunting and trapping. Of these, Ludlow and Mingo, two peaceable Seneca Indians had established their camp a short distance northeast of where the village of New Columbus is now located. With them were three women and four children. They had made a successful winter's work and had accumulated a stock of furs of considerable value. When this group of Indians were seated around their camp-fire, Thomas Harper, Andrew Sawyer, James Hudson, John Bridges, Sen., and John Bridges, Jr., five white men, came to the camp, professing to be hunting stray horses. They requested Ludlow and Mingo to assist them in the search, which was assented to. They divided into two companies, led by the two Indians, and entered the thick woods. They had gone but a short distance when Harper, walking behind Ludlow, shot him dead. Hudson, hearing the report of Harper's rifle, fired on Mingo, and he too fell dead. The band of assassins then returned to the camp and shot the squaws and the children, and robbed the camp of everything valuable.

Harper made his escape and was never heard of afterwards. He was probably pursued and killed by the other Indians then in that vicinity. The other four were arrested and confined in a log house at Pendleton, heavily ironed and strongly guarded. This murder aroused the Indians hunting in that region as well as the Miamis north of White River, who sympathized with them, and spread a panic among the cabins of the white settlers. John Johnson, the Indian agent for the Senecas residing at Piqua, Ohio, and William Conner, acting agent for the Miamis, instantly came to the scene of disturbance and quieted the Indians by assuring them that the murderers should be promptly and properly punished for their crime. Johnson immediately sent an account of the murder to Washington, and the Department appointed James Noble, at that time one of our Senators,

to lead in the prosecution of the case. A special session of the court was convened, Judge Wick presiding. Hon. James Noble, Calvin Fletcher, Philip Sweetser and Samuel Mason appeared for the State. The prisoners were defended by Charles H. Test, James Rariden, Martin M. Ray, William B. Morris and Lot Bloomfield, Esqs.

Though the court was convened in a rude log cabin, yet the Court of the Queen's Bench could not have been conducted with more gravity and formality than was this first criminal court of Madison county. A backwoods jury, in their moccasins and hunting shirts, patiently listened to the same bloody recital day after day, as each case came up for trial, and gave close attention as the array of legal talent waded through the intricacies of the law and the quirks and tricks of sophistry common to the criminal lawyer; and at the conclusion of each case brought in a verdict of "guilty," varying the monotony only in the case of John Bridges, Jr., who was commended to the Executive clemency on account of his youth and his testimony on which, chiefly, the others were convicted. A deep feeling of indignation was aroused among the spectators by the diabolical plot of cold-blooded murder and robbery as it was brought out in the testimony, yet no attempt at violence was made, nor a hint at Lynch law heard; and even the "red men" who were present, many of whom understood English, behaved with the utmost decorum, and appeared to be deeply interested in the proceedings. The sentence of death by hanging was duly executed on Hunter, Sawyer and the elder Bridges, and John Bridges, Jr., who was but sixteen years of age was reprieved by Governor James Brown Ray, on the scaffold. The hanging took place at the foot of the hill, a few yards east of the railroad bridge, and near what is now the roadside. The execution was public, and was witnessed by almost the entire population of Madison and the neighboring counties, including a number of Indians, who expressed themselves entirely satisfied with the white man's mode of administering justice. This piece of history is of more than local interest. So far as my reading informs me, it is the only instance since the formation of the United States government where white men were hung for killing Indians.

TOPOGRAPHY AND DRAINAGE.

That section of Madison county lying east and south of the Bee Line railroad, and drained by Fall Creek and its tributaries, has an undulating surface, in some places almost hilly, the elevations consisting generally of beds of gravel and bowlders, marking indelibly the foot-prints of glacial action. This is especially true of a belt three or four miles wide, extending from Lick Creek, three miles southwest of Pendleton, in a northeastern direction, along the southern side of the prairie, crossing White River at Anderson and following the course of Killbuck Creek to the line

of Delaware county. These gravel hills have generally a sufficient covering of a sandy, clay loam, to secure to them a high degree of fertility. At some points, however, on the south of Prairie Creek, the gravel is hardly covered at all, and the surface sustains only a dwarfed and stunted growth of oak and black hickory timber. But such gravel knobs are local and rare. These gravel ridges sustained the earliest settlements of the county and still confirm the correctness of the pioneer's judgment of their fertility. The valleys between them abound with numerous springs, some of which are hardly excelled in volume and purity of water, by any in the State. Northwest of this belt the country is generally level, the smaller streams lying almost on the surface. Gravel banks are so rarely found that in many places there is a difficulty in procuring good gravel for the construction of roads.

The drainage of Madison county is effected through White River, Fall Creek, Pipe Creek, Killbuck Creek, Duck Creek, Stony Creek, Lick Creek and Prairie Creek. Besides Killbuck, White River receives no tributaries of any considerable size in this county. This is accounted for by the fact that Fall Creek and Pipe Creek, which enter White River below the county line, run at an acute angle with White River, and but a little distance from it on either side. Lick Creek joins Fall Creek near the southwest corner of the county. It is a long stream, rising in Henry county, and flows across the sounth end of Madison county parallel with Fall Creek, and at no point more than four miles from it. Prairie Creek was originally the slough of a wet prairie extending from Fall Creek, at Pendleton, nearly to White River, a short distance below Anderson. It is now drained by a ditch nearly eight miles long, which is known as Prairie Creek. Six miles of it drains to Fall Creek and two miles to White River. The original prairie, which is from half a mile to two miles wide, is now chiefly dried and in cultivation, pasture or meadow. Fall Creek is notable for a cascade, or perpendicular fall of ten feet, over a ledge of sandstone. It furnishes an excellent water power which is now utilized in propelling a large flouring mill. Pipe Creek rises in Delaware county and flows through a comparatively level country in a southwesterly direction, and joins White River a mile below the western line of the county. Killbuck enters White River opposite to Anderson. It drains the central and eastern parts of the county, which is a pleasant undulating country with generally a very fertile soil.

Duck Creek, in the northwestern corner of the county, and Stony Creek, between White River and Fall Creek, rise in marshy districts in Madison county, and empty into White River, in Hamilton county. They are surface streams in their upper course, if indeed it be proper to call them streams, as they are made of several public ditches, converging into a common ditch of a larger size. Township 22, on the north line of the county, stretching across three ranges, has no drainage except by public

ditches. These are made from ten to twelve feet wide and generally five feet deep, so as to give ample outlet to the tile drains that are being used everywhere. In this manner what was once deemed waste land is now being converted into the best quality of tillable soil, exceedingly productive and almost indefinitely durable.

This county was originally almost entirely shaded with a heavy forest of oak, ash, walnut, beech, sugar tree, hickory, elm, etc., but much of it has disappeared.

GEOLOGY.

The greater part of Madison county is covered with a deep deposit of glacial drift, but the few streams which cut through it and reveal the rock in place, indicate that the eastern and northern parts of the county rest on rocks of the Upper Silurian age, but in the southwestern corner, embracing Greene, and parts of Fall Creek and Stony Creek townships, the underlying rock is Devonian. The falls of Fall Creek, at Pendleton, furnishes the boldest and most remarkable outcrop of rock in the county. The ledge forming the cataract is composed of heavily stratified sandstone of a peculiar structure. It consists entirely of quartz crystals of pretty uniform size, and but feebly held together, sometimes by a cement of peroxide of iron, but more frequently by no visible force, and therefore much disposed to crumble; yet it has a wonderful power to resist the action of water. The ledge over which the water falls at Pendleton has scarcely undergone any change since the white man first became acquainted with it, sixty years ago. The great ice floods of the last two winters broke through the sandstone floor which received the falling water, and exposed the Niagara shale below, which is now being rapidly excavated, and will, unless arrested, ultimately undermine the falls. This occurrence revealed the lower margin of the sandstone; its upper surface had already been exposed in the quarry of the Bee Line railroad, where the junction with the overlying limestone had been reached. This evidently belongs to the Devonian age, and to the Corniferous period of that age. The Pendleton sandstone, therefore, lies in the debatable ground between the closing Silurian age and the dawning Devonian time; and the mixed condition of its fossils clearly indicates its neutral ground. Its brachiopods and corals are Devonian, while its univalves and articulates are of Silurian types.

This Pendleton sandstone has been generally overlooked by geologists, or at most, been regarded as an accidental occurrence. But Hall, Dana, and other eastern geologists, as well as Lyell and Verneuil, from beyond the Atlantic, have located the Oriskany sandstone in exactly this position, and assigned to it lithological characteristics and fossils, which very accurately describe the Pendleton sandstone. West of the Appalachian region the Oriskany sandstone has been identified in the State surveys of Illinois, Michigan and Missouri. In 1854, in attempting to trace the out-

lines of the several formations comprised in the geology of Indiana, I followed the outcrop of this peculiar sandstone from the old millstone quarries on Sand Creek, by Greensburg, the forks of Clifty, crossing Little Flatrock near Milroy, appearing again at Pendleton, and on Stony Creek, in Hamilton county, crossing White River at Strawtown, and the Wabash a few miles below Logansport, and was lost under the drift beyond. In all this distance it forms as distinct a line of demarkation between the Silurian and Devonian formations, as does the Genesee slate between the Devonian and Carboniferous ages. The best marked exposure of this rock in the State is this at Pendleton, though the entire exposure does not exceed twenty feet in thickness, including several Calciferous strata at the base of the overlying Corniferous limestone. It is a very durable building rock, but is difficult to quarry, having no lines of cleavage, and its very sharp grit cuts the tools severely in dressing it. Its feeble cohesion forbids the method of quarrying by means of blasting, though this method is in use here now.

The Calciferous strata overlying the sandstone appear in the bed of the stream at Huntsville, a mile above Pendleton, on Fall Creek. The sandstone makes a very fair outcrop at Fishersburg, near the Hamilton county line, but its thickness at this point could not be ascertained, as its base is not exposed; the fossils observed here were all of them corals of the Favosite family. While the Pendleton exposure of this sandstone abounds in very perfect siliceous petrifactions, casts, or moulds, yet but a few species are represented. We collected here the following:

Favosites—several undetermined species, *Pleurotomaria lucina*, *Conocardium trigonale*, *Strophodonta demissa*, *Tentaculites* Spec.(?), *Phragmoceras nestor* (Niagara—near Anderson), *Phacops rana*, *Heliophyllum* Spec.(?), *Stromatopora densum*, *Turbo shumardi*, *Naticopsis humilis*, *Spirifera gregaria*, *Loxonema* Spec.(?), *Pleurotomaria* Spec.(?)

The Corniferous limestone which outcrops at Foster's Branch, four miles below Pendleton, and at a point near the county line, might be quarried to advantage, especially the outcrop at Foster's Branch. The rock at this point is compact, crystalline limestone, and will prove a durable material for foundations, cellar walls, etc. Fossils are very rare in this rock. I observed only a few detached joints of crinoid stems and an imbedded fragment of a favosite.

The Niagara limestone appears at several points along White River, in its course through this county, but quarries have been worked profitably only at a point a short distance below Anderson (Sec. 11, T. 19, R. 7). At all the outcrops of stone on the river, which we observed, there is a deposit of clay shale from five to ten feet thick overlying the workable strata of rock. Add to this fact that in the process of quarrying occasionally a stratum occurs too shaly to be marketable, and its removal from the quarry is a matter of expense instead of profit. Notwithstanding

these obstacles much good building stone has been raised from these quarries, for use in the city and the adjacent country, as well as for transportation by rail to other points. The strata are from ten to twelve inches thick. In the prairie about two miles southwest of Anderson (Sec. 23, T. 19, R. 7) the drainage ditches encountered limestone of an excellent quality, from which the overlying shale has been removed by the glacial agency. If the ditch was deepened by blasting, so as to secure drainage to the works, and a switch from the railroad constructed into it, a quarry of great value might be opened here.

Limestone, of a fair quality, appears at three points on Pipe Creek. Near Frankton a quarry has been opened for town and neighborhood supply, but at present it is not being actively worked. Two miles northeast of Frankton, in Sec. 33, T. 21, R. 7, a quarry is worked for local supply. A large amount of stone of a fair quality has been removed from this quarry and much more is stripped and ready to be raised. The stripping is quite heavy, and there is considerable waste from unmarketable strata in the quarry. Near Alexandria stone appears in Pipe Creek and in Mud Creek, a tributary from the north. At neither point has a quarry been regularly opened, though stone has been taken from the Mud Creek exposure to some extent, and surface appearances indicate that a good quality of rock for ordinary uses might be obtained here with but little expense, as the stripping is comparatively light, and its convenient distance from town and from two railroads promises a profitable working of this quarry.

GLACIAL AGE.

The Ice age has left distinct foot-prints on the southeastern section of Madison county. A line drawn from near the northeast corner of Richland township to Anderson and continued in the same direction down the valley of Prairie Creek by Pendleton to the southern line of the county, will traverse a region of valleys of erosion between hills of washed gravel deposited by currents from beneath the dissolving glacier, while the finer and lighter materials were carried forward to form the clay surface of the counties south. The most distinct remains of a lateral morain that I have seen anywhere is in the piles of gravel and bowlders that skirt the southeastern side of the glacial river bed which stretches from White River to Fall Creek in what is now known as the Prairie.

This valley of erosion has an average width of about a mile and is sunk some thirty feet below the general level of the country, while the gravel a ong the southeast side is piled up from forty to fifty feet high. The valley crosses Fall Creek and continues somewhat narrowed to Lick Creek near the Hancock county line. At the point of crossing Fall Creek bowlders of granite, gneiss and trap rock are profusely distributed over several hundred acres of land. Southeast of this line gravel hills are abundant

and the soil generally is a sandy loam. North and west of this gravel beds are rare, and as the northern line of the county is approached they entirely disappear. Sand banks are occasionally found and this is substituted for gravel in the construction of roads. Gravel is, however, occasionally found in this section of the county where nothing on the surface indicates it. Water for domestic purposes and for stock is easily procured by wells from twenty to thirty feet deep, and in the Fall Creek regions springs are numerous.

ARCHÆOLOGY.

The most remarkable relics of a pre-historic race, and, perhaps, the best preserved works of that race to be found in the State, or perhaps in the United States, are in Madison county. They consist of two groups of earth-works, located on a high bluff south of White River, three miles east of Anderson city. They were formerly known, in the neighborhood, as the "Old Fort," but now are generally called "The Mounds," neither of which appellations are strictly correct. These works have been described in detail in the eighth volume of the Geological Reports of Indiana (1878), and I do not choose to repeat the details here.

In general terms, I will say that these works consist of two groups situated three-fourths of a mile apart. The first, or southwestern group, consists of seven embankments and a low mound. Four of these are perfect circles, three have a gateway through the embankment and two have a distinct ditch on the inside of the embankment. Two are irregular ellipses in shape, or, rather, they are two circles of unequal size, so joined that the distance from centre to centre will be equal to the radius of the smaller circle. They have each a well defined ditch inside of the embankment. Of these one is nearly double the size of the other and the larger one has a low mound at the junction of the two circles. The great circle, which appears in some respects to have been the type of all the others, is situated at the east and north of the group. It consists of a circular embankment of compact clay, 380 feet in diameter and nine feet above the level of the earth on the outside. It has a base of sixty-three feet and a level summit of ten feet. Inside of the embankment is a ditch ten feet deep and sixty feet wide at the surface. The central area is 138 feet in diameter and in its centre is a truncated or flat-topped mound thirty feet in diameter and four feet high. Looking a little west of south from this centre is a gateway thirty feet wide, where neither the embankment nor ditch closes. On the central mound of this great circle a slight excavation revealed ashes, charcoal and calcined bones. The same evidence of fire was found in the central mound of the double circle before described. In none of the minor works do the embankments exceed four feet high, nor the circles 180 feet in diameter. The other group is located near the northeast corner of section 16 and on the summit of a

bluff of White River seventy-five feet high. It consists of three principal works, the largest of which is an embankment and ditch of an irregular elliptical form with its axis directed to the southeast, which is the smaller end of the ellipse. At this end is a gateway nine feet in width, the external opening of which is guarded by two small mounds, one on either side, at present about four feet high. The dimensions of this work measured through its longest axis, is 296 feet, and its greatest width, 160 feet. The embankment is thirty feet wide on its base and from four to five feet high. The ditch is eight feet wide but in many places nearly filled. The central area shows no sign of any mound or other artificial work. This work, with the exception of the gateway and guarding mounds, is in a primitive forest, but these last are rapidly disappearing under the influence of cultivation. Near this is a work of nearly the same shape but of less than half the size. It is constructed on the same plan, except the sentinel mounds at the gateway. A plain circle in a cultivated field near by completes this group. It is 150 feet in diameter, without gateway or any other appendage. The embankment is represented by the early settlers to have been three feet high originally, but is now rapidly disappearing under the action of the plow.

That these wonderful relics belong to a race of men who used no metal tools is inferred from the numerous stone implements collected in this vicinity and the absence of anything metallic, even copper ornament. It would be in vain to conjecture the age of these works. It is true large forest trees are now growing on them, but this can carry us back but two or three centuries at most, and this, probably, is but an inconsiderable fraction of their age. If these walls had been built of stone, we might, in the action of weather on it, have an index of its age, but banks and mounds of clay in a sheltering forest leave no marks to count the passing centuries. The object and purpose for which these works were constructed is a problem almost as difficult to solve as their age.

Many of the pre-historic earth works in Indiana were for military defense. The Winchester embankment enclosing thirty-one acres, with its central lookout mound, is evidently of this character; as is also the stone works at the mouth of Fourteen Mile Creek, in Clark county. But these works have no military features about them. They are too small to accommodate a military force, and the uniform ditch on the inside of the embankment forbids the idea of military defense. They were probably intended for the exhibition of public ceremonies, either civil, theatrical, or religious. The fact that two of the largest works in the lower group, show ashes, coals and fragments of bones near the surface on their central mound, would suggest the idea of sacrifice, and tend to confirm the suspicion of a religious use. But this is a mere conjecture, and, perhaps, no evidence will ever be obtained that will carry us beyond this.

Whatever may have been their use, these works were not constructed

by sparsely scattered savages who lived by the chase, nor by nomadic tribes that lived a pastoral life. The country must have been densely populated by a race inured to labor, and skilled in the art of design. The symmetry of form, and the skill manifested in constructing curved embankments and ditches with a uniform slope, attest this. When we consider the rude tools with which they must have worked, and the quantity of compact clay removed, we begin to comprehend the magnitude of the labor performed. Another question as puzzling as any of these is: Where are the remains of the people who constructed these works? There are no burial mounds in this vicinity, and more than a solitary skeleton in a gravel pit here and there, has not been discovered. How did they dispose of their dead? Did they cremate them, or, has time destroyed even their bones?

But I wish to propose a matter more practical than these speculations. These works are, as yet, in a state of perfect preservation, covered by the primitive forest, but they may pass into other hands, and the greed of gain may remove the forest, and the plow may, in a few years, obliterate the last trace of the labor of our mysterious predecessors. Steps should be taken at once to preserve these works as a memento of the past, to excite the wonder of future centuries. How this should be done, I would not dictate. If the State would purchase it for a public park, and secure it, as the Tippecanoe battle ground is now secured, these vestiges of past centuries and of a lost race may be preserved. In behalf of science I earnestly appeal to the public to secure these works from the destruction that may come on them any day, while they remain the property of private owners.

A mound of an elliptical shape, eighty feet long and fifty feet wide, was examined in section 5, township 18, range 7. It is in a cultivated field, and is, at present, about six feet high, but is being rapidly reduced by cultivation. Stone axes and flint arrow points are frequently found in this vicinity. No excavation of the mound has been made.

NATURAL HISTORY.

The territory comprised in Madison county was once a favorite hunting ground of the red men. In addition to the wild animals common to a forest-covered country of this latitude, it was a special resort of the beaver, the otter and the muskrat, the furs of which were so highly prized by the primitive trappers. Remains of beaver dams are yet visible in what was once the broad sluggish sloughs near the heads of Stony Creek, Pipe Creek and Duck Creek. But the game and fur animals have long since disappeared, and scarcely a squirrel remains as a reminder of this paradise of the hunter. The fish that once abounded in all the streams in this county, following the forest game, have nearly disappeared from the waters.

The flora of this region was originally rich and varied, but cultivation and free pasturage have left but a narrow range for the botanist. The gravel hills south of Prairie Creek, however, will be found rich in rare plants, the study of which will well repay the scientist. The season of my visit was too late for the favorable study of this field, the greater part of the plants having passed their blooming. On this account, I did not attempt a collection of the rare plants found here.

There are several natural groves of chestnut trees (*Castanea vesca*) found growing in the vicinity of the ancient earth-works near Anderson. Whether these have any connection with the antique remains I have no means of determining, but the fact that chestnut, as a forest tree, is not elsewhere found within a hundred miles of this location, is suggestive of a connection at least.

GENERAL SECTION OF HAMILTON AND MADISON COUNTIES.

Quaternary Age.

Alluvium	10 to 40 feet.
Glacial drift	10 to 100 feet.

Devonian Age.

Corniferous limestone	50 to 60 feet.
Oriskany sandstone	12 to 15 feet.

Upper Silurian Age.

Niagara group	40 feet.

Geological and Topographical Survey

of

FAYETTE COUNTY, INDIANA.

BY MOSES N. ELROD, M. D.

1884.

GENERAL AND DESCRIPTIVE.

Fayette is one of the eastern central counties of the State. It is bounded on the east by Union, on the south by Franklin, on the west by Rush and Henry, and on the north by Henry and Wayne counties. Its area includes 225 sections of land, and has 135,302 acres reported for assessment. In 1883 the real estate was valued at $3,835,355, and the personal property at $3,817,009; total, $7,652,364. The total valuation of taxables in 1884 was $7,584,709. According to the Third Annual Report of the Bureau of Statistics, it takes rank as the third county in the State in *per capita* wealth.

The intelligence, thrift and energy of the people of Fayette county early led to investments in the construction and operation of the White Water Canal. Since the building of railroads it has ceased to be an avenue of trade, but is still utilized by various hydraulic companies in furnishing water to drive the machinery of flouring and other mill interests.

The Cincinnati, Hamilton & Indianapolis railroad crosses the county from east to west, and the White Water Valley road follows the tow-path of the old canal, from north to south. The Fort Wayne, Muncie & Cincinnati railroad forms a competing and parallel line with the Valley road from Wayne county to its junction with the C., H. & I. R. R. at Connersville. The Cambridge Branch of the Jeffersonville, Madison & Indianapolis railroad crosses the northwest part of the county through Posey township. All the railroads of the county, except the Cambridge Branch, cross and centre at Connersville.

The county is supplied with an excellent system of pikes and gravel roads, uniting the towns and villages with each other and with the county

seat. Among the leading toll and free pikes are the Connersville and Rushville, Connersville and Fairview, Connersville and Bentonville, Connersville and Brownsville, Connersville and Richmond, Connersville and Liberty, Connersville and Everton, Connersville and Waterloo, and Waterloo and Brownsville. With good country roads, many of them graveled, and railroad facilities to meet the commercial wants of the county, the various and rich agricultural products of the farmer are rapidly and cheaply marketed.

Connersville, the county seat, is a beautiful city of nearly six thousand inhabitants, pleasantly located on the second terrace of the White Water River, 30 or more feet above high water. The original town was founded by John Conner, in 1813, and early in its history took rank as one of the principal towns of the State; renowned for the energy, intelligence and national reputation of many of its citizens, whose descendants, in the city and surrounding country, are maintaining the fair fame of their fathers. In proportion to size it takes rank as one of the first manufacturing cities in Indiana; and especially so in the number and capacity of its furniture factories, machine and carriage shops. Its streets are wide, regular, well graveled and paved, lighted with gas and efficiently policed. The court house is a substantial structure, apparently of ample capacity to accommodate the business of the county. The city is supplied with water from White Water River by the Holly system of water-works. Throughout the resident part of the city are many beautifully shaded streets fronting spacious yards and fine residences. East Connersville, just over the river, and Maplewood, on the north, are thriving suburbs of the city proper.

Glenwood (Vienna), on the C., H. & I. R. R., Falmouth on the Cambridge Branch of the J., M. & I. R. R., Fairview and Fayetteville on the line and partly within the limits of Rush county, are thrifty towns surrounded by as fine agricultural lands as the heart of man could wish. Bentonville, in Posey township, is another railroad town of two hundred inhabitants, in a rich rolling country. Alquina, in Jennings township, and Everton, in Jackson township, are next in point of size, and pleasant villages surrounded by an apparently happy and prosperous people. Nulltown and Alpine on the White Water Valley R. R., and Longwood, Tyner and Lyons on the C., H. & I. R. R., are post office stations and shipping points.

TOPOGRAPHY AND DRAINAGE.

What is known to geologists as the Cincinnati arch, or axis of an upheaval of the earth's crust that took place near the close of the Hudson River period of the Silurian age, has determined the altitude and general surface configuration of Fayette county. Observation shows that the top of this anticlinal, one of nature's first efforts at mountain making, was a comparatively level plain over southeastern Indiana with an average elevation, at

this day, of over 900 feet above tide water in New York harbor. The valleys and river banks now seen are the result of forces that have acted on the surface of the old Silurian plain after its upheaval. The western border of the Cincinnati arch passes through the north part of Orange township, one and a half miles east of Glenwood, and through Posey township, two and a half miles northeast of Falmouth; which in its northern and southern extension forms the divide between the White Water and White River valleys. West of the divide the descent to the southwest is gradual and nearly corresponds to the dip of the Niagara limestone at the rate of 16 feet to the mile, while the rivers and creeks increase in fall as they gain in volume and excavating power, from small surface rivulets flowing over the clay and gravel, to large streams that cut under the dip, down and into the stone with moderate bluff banks that seldom exceed 50 feet in height. East of the divide as shown by the table of altitudes of the Cincinnati, Hamilton & Indianapolis Railroad, the descent is much more precipitous over a region of country devoid of any or but a slight dip. The Glenwood summit has an elevation of 1,116 feet, that compared with the bed of White Water River at Connersville shows the difference of altitude to be 308 feet in eight miles. On the west, the difference between the summit of the divide and the bed of Flat Rock River, at Rushville, in fourteen miles is 159 feet, making the rate of descent on the west 11.42 feet per mile to 38.52 feet per mile on the east, or as 1 to 3.5.

Whether the Cincinnati arch is higher at the western border in Fayette county than the eastern interior I could not accurately determine, but by a comparison of the junction of the Lower Silurian with the overlying Clinton group at the railroad bridge across Big Williams Creek and the Glenwood summit, I find the difference to be 160 feet in three miles. The railroad summit east of Longwood shows an eastern descent of 52 feet; that of the summit west of Connersville 156 feet, and that of the summit west of Lyons 174 feet. East of Liberty, in Union county, the summit, natural level of the country, between Lotus and Cottage Grove, has an altitude of 1,090 feet, which is only 26 feet less than that of the Glenwood divide. In this connection the tables show that the bed of East White Water River at Brownsville is 35 feet lower than the bed of West White Water at Connersville, but I do not conclude from this that the synclinal of the White Water valley is along the course of the East Fork, for the reason that the valley in the vicinity of Connersville appears to be partially filled with gravel that may cover deeply the under-lying stone. That the White Water valley had an existence early in the geological history of Indiana, long before the Drift period, is rendered highly probable by the absence of any considerable depression that might have been the bed of an ancient river crossing the divide, from Pierceville in Ripley county to Bentonville in Fayette county, and the vast amount of rocky material that has been removed from what was once a plain to form the

valley. The old Lower Silurian island which now underlies nearly the whole of Fayette county, had a system of drainage, in the main, identical with that of to-day; identically the same, except where changed by the deposits of the Drift period.

The reported elevation on the Fort Wayne, Muncie & Cincinnati railroad gives the altitude of the track, where it crosses the Fayette county line, at 881 feet, and the track at Connersville at 838 feet above the ocean, a difference of 43 feet. Surveys made for the White Water Canal in 1834 give the surface of the ground at the Connersville court house at 845 feet, and the surface of White Water River at the junction of the East and West Forks, below Brookville, at 620 feet above tide water, a difference of 225 feet. These altitudes show a gradual descent to the south at the rate of 12 feet per mile on a direct line.

The reader is prepared to understand from the foregoing observations that as a rule the surface of the country is level. The water courses and ravines running into them are bordered by bluffs that are the result of excavating forces that have carried their beds and valleys below the general surface. The creek and river front of the bluffs are steep, but very seldom rocky. Back of the bluffs the surface gradually rises to the watershed between the creeks. Those on the creeks are generally bold, while those on the White Water River are sloping or rounded and, viewed from the river valley, impress the eye as hills broken by cross valleys and ravines. From the elevated points along the valley, and from the bluffs of Big Williams Creek, delightful views of the country can be had, embracing beautiful farms dotted with fine residences, the homes of an intelligent, happy and prosperous people. On the west side of the county, including Orange, and especially Fairview and Posey townships, the land is level or slightly rolling, and in places was wet and swampy, before a system of artificial drainage was put into successful operation. Harrison township and the townships east of White Water River are rolling, with occasional slight ridges and elevations. On account of the creek bluffs the west parts of Connersville and Columbia townships are the most broken parts of the county, but here the vast body of the land is tillable with the plow, and almost every foot is available for blue grass pasture. The rounded and long sloping fronts of the bluffs are covered with a deep bed of yellow clay that is invariably fertile. From north to south through the central part of the county runs the White Water valley proper, having an average width of three miles, and bordered by fertile and in places heavily wooded bluffs that rise nearly 200 feet above the valley plateau. This body of valley land, rich and easily cultivated, is one of the garden spots of the world.

The drainage of the county is effected through numerous small streams, that, with a few unimportant exceptions, are confluents of West White Water River. In former years, before the land was underdrained and

ditched, when the primeval forest in all its grandeur covered alike the valleys, bluffs and upland, many of these little creeks were living streams of water, with mossy, fern-covered banks. Now they are changed into unsightly ditches that are flushed with muddy water only after heavy rains. The summer pools, shimmering in floating patches of shade and sunshine that stole through an arching canopy of green, with their finny inhabitants are gone. Destructive man, without due thought for the future, has exposed the relentless hand of nature, where the beautiful and useful might have been preserved, the love of sylvan haunts encouraged, and extremes of drought and flood in part averted.

Noland Fork Creek unites with White Water River just below the Wayne county line, and is consequently an unimportant factor in the drainage of the county. On the west side of White Water the principal creeks are Lick Creek, Big Williams Creek and its tributaries, Hurricane and Little Williams Creeks and Garrison Creek. Lick Creek is a small tortuous stream with low clay and gravel banks, confined in its course to Harrison township. Big Williams creek rises in Posey and Fairview townships, and before the present system of artificial drainage, was fed from swamps and ponds on the White River and White Water divide or water-shed; formerly it had quite a reputation for furnishing adequate water power to a number of flour mills. North of Connersville township its banks are low and bordered with sand and gravel; for the rest of its course its banks are high and rocky without first or second valley bottoms. The track of the C., H. & I. railroad bridge, where it crosses the creek, is seventy-five feet above the bed of the creek, and the banks grow higher until it passes out through the bluffs into the White Water valley. Hurricane Creek is a short stream that is worthy of note in this connection on account of its steep, rocky banks; its bed at the railroad crossing is thirty-two feet above the bed of Big Williams Creek at Longwood. The bed of Little Williams Creek does not reach down to the stone. Garrison Creek rises in Orange township and flows through Columbia township; for the most part of its course its channel is rocky. On the east side of the river are a number of small streams not usually given on maps of the State that have their origin on the water-shed between the east and west forks of White Water. Bear Creek, a larger creek than those referred to above, empties into White Water a mile or more below Alpine, and is quite rocky in its lower course.

TABLE OF ALTITUDES, FAYETTE COUNTY.

Cincinnati, Hamilton & Indianapolis Railroad.

Miles from Indianapolis	POINTS AT WHICH THE ELEVATIONS ARE TAKEN.	Feet above Ocean.
47.4	Glenwood (Vienna)	1,092
	Summit, 2½ miles east of Glenwood, natural surface	1,116
	Hurricane Creek, natural surface	952
	Big Williams Creek bridge, grade line	995
	Big Williams Creek, bed of stream	920
51.8	Longwood, natural surface	1,111
	Summit, natural level of surface	1,059
	Little Williams Creek, bed of stream	889
54.7	Tyner, natural surface	936
	Summit, natural surface	959
55.9	Salter's Switch, natural surface	919
57.1	Connersville	884
	West Fork White Water River bridge, grade line	840
	West Fork White Water River, bed of stream	807
	Turnpike, 1 mile east of Connersville	853
	Summit, natural level of surface	951
61.5	Lyons, natural surface	896
	Brownsville and Connersville turnpike	863
	Summit, natural level of surface	889
	East Fork White Water River bridge, grade line	802
	East Fork White Water River, bed of stream	773
71.4	Liberty	992

White Water Valley Railroad.

89	Valley Junction, level of track	511
90.7	Dry Fork Creek, bottom of stream	491
9[illegible].5	Harrison, level of track	533
108.2	Big Cedar Creek, bottom of stream	585
113.9	East Fork White Water River, bottom of stream	615
114.7	Brookville, level of track	6[illegible]7
122.8	White Water River	714
130.7	Garrison Creek, bottom of stream	747
135.8	Big Williams Creek, bottom of stream	764
139.6	Connersville, level of track	832
142.8	Lick Creek, bottom of stream	861
145.2	Beeson's, level of track	889
151.2	Simons Creek, bottom of stream	922
152.2	Cambridge, crossing P., C. & St. L. and J., M. & I	952
155.7	Nettle Creek, bottom of stream	986
155.9	Hagerstown, connection with P., C. & St. L. R. R	1,003

ALTITUDES—Continued.

Other Points in the County.

POINTS AT WHICH THE ELEVATIONS ARE TAKEN.	Feet above Ocean.
Falmouth, base of rail at station.	1,061
Highest point on Cambridge branch J., M. & I., base rails . . .	1,084
Bentonville, base of rail.	1,066
Track at Fayette county line, Ft. W., M. & C. R. R	886
Track at Connersville, Ft. W., M. & C. R. R	838
Bed of Big Williams Creek, Bunker Hill, Prof. Owens	860
Court house yard, Connersville, canal surveys, 1834	845
Junction East and West White Water, canal surveys, 1834 . . .	620
Junction of Lower Silurian and Clinton, at Longwood	956

GENERAL GEOLOGY.

All the native rocks of Fayette county, underlying the Drift clay and gravel, that are exposed in digging wells, and the banks and beds of the creeks and ravines are referred in classification to the Silurian age, Upper and Lower Silurian divisions, and are related to each other and superimposed as shown in the following:

CONNECTED SECTION.

QUATERNARY AGE.

RECENT PERIOD.

Alluvium . . . . 5 ft.

DRIFT PERIOD.

Glacial Epoch.

Clay, gravel, sand and bowlders . . . . 100 ft.

SILURIAN AGE.

UPPER SILURIAN DIVISION.

NIAGARA PERIOD.

Niagara Group or Epoch.

Niagara group quarry stone as exposed on Big Williams Creek 40 ft.

Clinton Group or Epoch.

Siliceous or bastard limestone . . . . 20 ft.

LOWER SILURIAN DIVISION.

TRENTON PERIOD.

Hudson River Group or Epoch.

Limestone, shale and marl	200 ft.
Total.	365 ft.

HUDSON RIVER GROUP.

LIMESTONE, SHALE AND MARL.

It is remarkable that no blocks or fragments of native stone are seen scattered through the Drift clay or on the surface, except small masses seen in the channels of the creeks that have been torn from beds or detached from the banks of the stream. The entire absence of waste material of the native rocks from the Drift deposits, the result of erosive action, shows that the excavating forces acted slowly and that the formation of the White Water valley, with its network of branching creeks and ravines, existed long ages of time, perhaps thousands of years before the Age of Man.

It was not possible to obtain exact measurements determining the dip of the Lower Silurian, but from what I saw on Big Williams Creek, it is probable that as heretofore stated by Dr. Haymond in his Report on the Geology of Franklin County, Indiana Report, 1869, it is to southeast at the rate of 4 feet to the mile. Comparing 956 feet, as the elevation above the sea of the junction of the Lower Silurian with the Clinton group limestone at Longwood, just above the railroad bridge, with 953 feet as the junction of the same formations at Rossburg, in Decatur county, the difference is seen to be only 3 feet, and hence a very slight dip to the northeast. That there is no dip to the east, unless it be local, is shown by comparing 940 feet the average of seven determinations of altitudes of the top of the Lower Silurian on a line running nearly east of Fayette county, made by Prof. Orton, Geology of Ohio, Vol. I, with 956 feet the elevation of the Longwood locality. My observations together with those of Dr. Haymond show that the water-shed between the White Water and White River valleys does not follow in all its course the western border of the Lower Silurian arch. While the divide from McCoy's, in Decatur county, to Bentonville, in Fayette county, has nearly a straight course, the western border of the upheaval bears to the east from McCoy's until it touches the White Water valley near Metamora, thence west to the southeast corner of Orange township in this county, thence north on a line with the divide. As a result of this deflection from a direct line there is a depression or slight valley running east and west, and depressing the strata of both

Upper and Lower Silurian rocks in the vicinity of Clarksburg. This depression has a bearing on the exposure of the stone seen in the southwest part of Fayette county, and may to a slight degree affect the dip.

LIST OF FOSSILS FOUND IN FAYETTE COUNTY.

LOWER SILURIAN.

Monticulipora—several species.	
Protarea vetusta	Hall.
Streptelasma corniculum	Hall.
Orthis testudinaria	Dalman.
Orthis biforata	Schlotheim.
Orthis occidentalis	Hall.
Orthis sinuata	Hall.
Rhynchonella capax	Conrad.
Rhynchonella ventricosa	Hall.
Strophomena alternata	Conrad.
Murchisonia bellicincta	Hall.
Zygospira modesta	Say.
Raphistoma lenticulare	Emmons.
Bellerophon bilobatus	Sowerby.
Ambonychia costata	James.
Orthodesma rectum	H. & W.
Modiolopsis pholadiformis	Hall.
Calymene senaria	Conrad.
Favosites	Sp?

UPPER SILURIAN.

NIAGARA GROUP.

Stromatopora concentrica	Goldfuss.
Lichenalia concentrica	Hall.
Atrypa recticularis	Linnæus.
Retzia evax	Hall.
Orthis hybrida	Sowerby.
Meristina maria	Hall.
Meristina nitida	Hall.
Orthoceras annulatum	Sowerby.
Orthoceras crebescens	Hall.
Gyroceras elrodi	White.
Calymene niagarensis	Hall.

The Lower Silurian fossils are abundant in all the outcrops, but as they are generally imbedded in the solid stone, no good localities for collecting

cabinet specimens were seen by me; but that such localities exist, I have no doubt. All along the banks of Big Williams Creek from the Harrison township line and Lick Creek, good specimens of the more common and characteristic remains may be found. Fine trilobites, *Calymene senaria*, in an excellent state of preservation, have been found in the blue clay or marl, one-half mile south of the bridge across White Water, at Nulltown, on the east side of the river. Mrs. L. M. Greene, of Beeson's Station, is said to have first discovered the locality, and once had a fine collection of fossils from that place. Niagara group fossils are found in the limestone at the James Ochiltree quarry, but as a rule can not be obtained in good preservation. Miss Mary E. Martion, of Fairview, has a very fine *Calymene niagarensis* that came from the Niagara limestone beds of Garrison Creek, in Orange township. Mr. John Benedict, of Longwood, has quite a fine lot of fossils, collected by himself and Mr. Clay Benedict, in Fayette county. The list given above is by no means complete, and embraces only a few of the more common varieties.

LOCAL GEOLOGY.

LOWER SILURIAN.

The stone of this division occurs in strata varying from a few inches to a foot or more in thickness, alternating with parting of marl. In color it ranges from ochery to blue, and in texture from loose, shelly stone and clay to a hard, crystalline rock. Much of it is composed of a mass of shells and other organic remains, with scarcely enough carbonate of lime and magnesia to form a compact matrix. The partings and strata of marl vary in consistency, an occasional stratum is seen that has the hardness of stone or an indurated shale, while other layers are soft unctuous clays that are highly charged with calcium carbonate and readily effervesce with mineral acids. It is one of these soft, blue clay marl beds that constitute the famous trilobite beds of this and Union counties, and from my own observations am of the opinion that in both counties they are of the same geological horizon. No sections are given as none could be made in this connection showing the actual thickness of the different ledges. The following section taken on the old Connersville and Rushville pike, where it crosses Big Williams Creek, shows the general relation of the Lower Silurian to the overlying Niagara as exposed on the west side of the stream.

Section at Bunker Hill, Connersville Township.

Soil, yellow and blue clay	40 ft.
Niagara group limestone, top ledges cherty and thin-bedded, bedding heavy and stone massive near the middle of the outcrop and below; good quarry stone	35
Clinton group limestone, mixed with iron ore and flinty in part; portions hydraulic; some of the strata fair quarry stone	20
Hudson River (Cincinnati) group limestone, with marlite partings to the bed of Big Williams Creek	30
Total	125 ft.

In former years, while the White Water Canal was being constructed, large quantities of stone were taken from the banks of Big Williams Creek for use in building the locks of the canal, and for the foundations of the Connersville court house. From what I saw, and comparisons made, I come to the conclusion that the bulk of the stone then quarried came from the Clinton group strata. Portions of this stone seen in the locks of the canal have stood the test of time and show sharp angles and square fronts, while other portions have scaled and some have almost crumbled to dust.

The Lower Silurian outcrops in the bed of Big Williams Creek, throughout its course in Connersville township, in the bed of Lick Creek on the road from Connersville to Harrisburg, on Dillman's Creek, near Waterloo, in the banks of Bear Creek, near its confluence with White Water, and at different places on Garrison Creek, in Columbia township.

UPPER SILURIAN.

CLINTON AND NIAGARA GROUPS.

As all the quarry work now being done in the county is confined to the Niagara beds, the Clinton limestone was only seen at isolated points where only an imperfect study could be made, but there is no doubt in my mind that the strata of rough limestone mixed with more or less siliceous matter and iron ore, is referable to the Clinton epoch. Its quality as a building rock has already been discussed. Much if not all the heavy stone formerly used in the county came from the Clinton beds. The strata are generally massive, coarse grained bastard limestones that are much discolored with iron ore. Some of the ledges show heavy bands of iron ore filling the seams and adhering to the surface of the stone. I only saw outcrops on Big Williams Creek.

The Niagara group limestone overlies the Clinton, and is consequently more exposed to the surface than the other groups that are seen only in the banks of the creeks. The Niagara is the surface stone underlying the drift deposit of the county west of the White Water valley, that is struck

in sinking wells on the uplands. It is the country rock of nearly one-half of the county. It is exposed in the bluffs of Big Williams Creek, from the Harrison township line south, in the banks of Garrison Creek, and on Sein's Creek near the county line.

From the following sections it will be seen that the Niagara limestone ledges range from 1½ to 9 inches in thickness. The bedding, like that of all the Niagara outcrops, is remarkably even and uniform for many feet in every direction, showing that the conditions under which the stone was formed were the same over a wide expanse of surface, and undisturbed by rapid or counter and conflicting currents. Some of the upper ledges are mixed with nodules and irregular plates of chert, but as a rule much the greater portion of the strata are beds of clear limestone of the finest quality and uniformity of structure. So far as I saw it, the Niagara stone of Fayette and Franklin counties with very few exceptions was of an ochery color, quite different from the gray, drab or blue color of the equivalent beds of Decatur and Shelby counties. On account of its yellowish ochery color, some of the top ledges that are in contact with the yellow clay have a sodden, rotten appearance that careful examination shows to be due to the color only. The heavy ledges are frequently relieved with patches of blue that show beautifully mottled surfaces when the stone is hammer-dressed. These soft tints so seldom seen in the hard gray limestone reminds one of the brown stone so popular for building purposes in the East.

Mr. J. T. Washam, section 30, township 14, range 12 east, has shown what can be done with this stone in a practical experiment in building a country residence where the soft tinted and variegated stone has been used in the structure. The walls are 18 inches thick, laid of 18-inch ashlar stone placed on the edge, and bound with a course of the same stone placed flat, as in the natural bedding. The building presents a massive and pleasing appearance, and will doubtless last for ages. The inside is plastered directly to the walls, and has not shown signs of dampness even in the closed closets. Before using the stone Mr. Washam tried a simple experiment to test its power to resist the influences of change of temperature and moisture by placing seasoned specimens of the stone in water for a number of years, where it was alternately exposed to the dry heat of summer and the freezing and ice of winter. After being thus tested the specimens, when broken, showed the same homogeneous dry interior as those kept continuously under cover, nor did they show signs of fracture or scaling.

In the Fayette county Niagara beds another desirable variety of building material is added to the vast store of available limestones known to exist in Indiana. The oölitic quarries of Lawrence and Monroe counties furnish the stone out of which is carved the endless variety of ornamental work used in architecture above a massive foundation of hard gray

limestone. From the Big Williams Creek quarries comes a stone which will compare favorably with the best as to durability, and be in demand as an ornamental stone for heavy masonry. Mixed with the gray stone of Decatur county the effect can not be other than pleasing to the eye, and in many styles of building, where it is desirable to harmonize tints, it will wholly supercede any other material.

To the usual chemical constituents of calcium and magnesium carbonates, as found in the Indiana dolomites, the Niagara of Fayette county seems to have added the usual amount of iron oxide in a higher state of oxidation, and it is to this that the ochery color is due.

Section at Wilson Ball's Quarry, one-quarter of a mile south of Longwood.

Soil and yellow clay	6 ft.	00 in.
Wall rock and curbstone, Niagara		4
Wall rock and curbstone		4
Flag, thin		2
Bridge and culvert stone		6
Dimension building stone		7
Dimension stone		6
Thin flag		2
Dimension stone		5
Dimension stone		9
Thin bedded soft stone, rotten at the bottom	10	00
Clay shale, lower Niagara beds	4	00
Clinton group limestone, reddish, hard and heavy bedded	20	00
Hudson River group limestone, with but little marly partings, to the bed of Williams Creek	20	00
Total	61 ft.	9 in.

Mr. Ball's quarries are on the east side of the creek. The work heretofore done has been confined to the banks and heads of the ravines, a few yards back of the creek bluff. The surroundings show that an unlimited amount of stone can be had with but little labor in stripping the stone of soil and clay. The product of the quarry is hauled on wagons to Connersville, or shipped by railroad at Longwood.

Section at J. T. Washam's Quarry—Sec. 30, *Tp.* 14 *N., R.* 12 *E.*

Three cherty ledges, 3 inches thick, Niagara		9 in.
Thin flags		5
Dimension stone		7
Dimension stone		6
Thin flag		2
Flag		4
Blue flag		3
Dimension stone, clouded		6
Thin shelly stone	6 ft.	00
Quarry stone in 6-inch ledges	15	00
Iron ledge, Clinton group		11
Clouded ledge of limestone		6
Blue stone		11
Blue stone		12
Rough stone to rock that will make fair lime, Lower Silurian(?)	12	00
Total	36 ft.	7 in.

This section is that of the quarry from which Mr. Washam obtained the stone for building his residence already mentioned, and includes the Clinton group stone down to the top of the Hudson River group.

Section at the Quarry of James M. Ochiltree, N. E. quarter Sec. 30, *Township* 14 *N., Range* 12 *E.*

Cherty ledges, Niagara group	2 ft.	00 in.
"Gudgeon," a worthless ledge	1	00
Flag		4
Rubble, cherty		6
Flag		4
Flag		4
Flag		4
Rubble that spauls		6
Dimension stone		8
Dimension stone		7
Blue flag		2
Blue flag		5
Dimension stone		10
Thin bedded stone that does not weather		12
Total	9 ft.	00 in.

This section was taken on the west side of Big Williams Creek, where a quarry has been opened in the bed and banks of a ravine that comes down the slope through a dense beech wood. The outcrop is exposed and worked for a distance of nearly 300 yards, and offers every natural advantage in operating a quarry with the least expenditure of money for stripping and disposal of the dump. The width of the ravine is favorable

to easy work, and the drainage all that could be desired; and the same is true of all the quarries seen in this vicinity. At the time of my visit to Mr. Ochiltree's quarry, a small rill was trickling over the shelving ledges, but in the banks where work was being done everything was as dry as could be wished for, considering the recent heavy rains.

Here and at Mr. Ball's quarry the work of raising the stone is effected with the usual supply of drills, bars, picks, hammers, wedges, etc., and the handling done without derricks. Better appliances for handling the output do not seem to be necessary at present, while the product is removed on wagons that can be readily driven to the place where the stone is quarried.

All the Fayette county quarries mentioned above can be connected with the C., H. & I. railroad by switches at a much less expenditure of money than has been made for the same purpose in other counties of the State, and I fully expect that such connections will be made within a few years.

QUATERNARY AGE.

DRIFT PERIOD.

All the vast accumulations of clay, sand, gravel, pebbles and bowlders found covering the country rocks of Fayette county are of foreign origin and referred to the Drift period. The black soil, and the alluvium of the valleys is referred to the Recent period or Age of Man. The relations of the various strata of Drift materials to each other and to the recent deposits of soil are shown in the following sections:

Average of Wells at Fayetteville.

Soil, black	1 ft.	to 3 ft.
Yellow clay	10	to 12
Blue clay	3	to 20
Total	14 ft.	to 35 ft.

Thomas Ochiltree's Well, Glenwood.

Soil, black	1 ft.	8 in.
Yellow clay	6	6
Hard blue clay	57	6
Sand, very fine	24	0
Hardpan, indurated blue clay	27	0
Stone, Niagara?	33	0
Total	149 ft.	8 in.

Well of Hon. W. W. Thrasher, Fairview.

Soil, black	3 ft.
Yellow clay	8
Blue clay	30
Sand, water bearing	. . .
Total	41 ft.

Well at Longwood, Connersville Township.

Soil, black	3 ft.
Yellow clay	10
Blue clay or hardpan	20
Sand, water bearing	. . .
Total	33 ft.

Wells at Everton, Jackson Township.

Soil, black	3 ft.	to 3 ft.
Yellow clay	8	to 10
Blue clay	10	to 20
Total	21 ft.	to 33 ft.

These wells give a fair average for the whole county, unless it be on the water-shed between White River and White Water, where the average is doubtless higher, and the Drift deposit exceeds 100 feet or more, as in the vicinity of Glenwood.

The component parts of the Drift may be arranged in the following divisions, commencing at the bottom: 1. Sand or fine gravel. 2. Blue clay or hardpan. 3. Yellow clay. Intermixed with these, but not so uniformly present, are two others of so frequent occurrence as to demand attention, and that are clearly the product of the same forces that deposited the other Drift materials; these are the *gravel beds* and *bowlders*.

1. The *sand* and *gravel* resting on the native rocks and underlying the blue clay is not of universal occurrence, but is seldom absent from the bottom of wells that reach down to the country stone. In physical appearance it is usually a bed of fine white sand, saturated with water, and is what is generally known as quicksand.

2. The *blue clay* or *hardpan* is the soft or indurated, struck in digging beneath the yellow clay. Generally it is a hardpan clay, dry and very difficult to dig, as it can not be penetrated with a spade, and the pick will detach no more than the width of the blade. The hardpan beds are impervious to water, and the imprisoned sheet of water beneath it on the slopes, when relieved of pressure, rises to the surface in the form of an artesian spring, as was the case of a well dug some years ago in the

barn-yard of Hon. W. W. Thrasher, of Fairview. When kept constantly moist by water from above it may become softened and assume the character of an unctuous clay. Occasional bowlders are found in it and show more evidence of grinding and polishing action than those of the yellow clay. I have a beautifully polished bowlder taken from the blue clay of a well 32 feet below the surface, by Mr. W. C. Moffitt, of Longwood. Intercalated beds and lenticular deposits of sand occasionally are met with, dividing the blue clay into two or more strata, as in the well of Mr. Ochiltree, at Glenwood.

3. The *yellow clay* stratum is the most generally distributed of all the Drift strata, the blue clay coming next, and everywhere present except in the creek and river valleys. Nowhere did I find it absent and the blue clay exposed on the surface. This fact has an important bearing on the agricultural interests of the county, as the yellow clay is always fertile and the blue clay only imperfectly so. As a surface clay the latter is known as the white or crawfish lands. The yellow clay contains a larger per cent. of gravel than the lower beds and a higher per cent. of bowlders and pebbles. On the high uplands of Orange, Fairview and Posey townships the ratio of gravel is diminished and replaced by fine sand.

The *black* soil of Fayette county is the only earthy matter that is of strictly local and recent origin. This is shown by its much greater accumulations over the flat surfaces and especially over portions of the county that were formerly swampy; those places most favorable to the growth and decay of rank vegetation and its accumulation at the bottom of the swamp or pond. It follows from this that the soil of Fairview and Posey townships is principally black, while that of the balance of this county is a mottled or mulatto soil; that is a soil of alternating patches of black and yellow clay with a lighter covering of black earth. The clay soil is the result of the yellow clay coming to the surface, and is the subsoil of the whole county except in the valleys.

Besides the gravel scattered through the clay beds and in greater per cent. in the slight ridges and hills on the upland, there are other accumulations in which the earthy matter is reduced to a minimum. The latter beds, aside from the vast deposits of the White Water valley, are mainly confined to the banks or bluffs of Big Williams Creek, and are of great economic value in road making. The following section, taken in the bluff bank on the west side of the creek, shows its relations and extent:

Section on Big Williams Creek, crossing of the Fairview and Harrisburg Road.

Soil and clay	5 ft.
Clean road gravel	12
Gravel and conglomerate masses to the water's edge	13
Total	30 ft.

On the farm of W. C. Moffit, S. W. qr. sec. 18, township 14 north, range 12 east, are other valuable beds that have been opened down twenty-one feet to the water-bearing gravel.

The White Water valley throughout its course in the county, and with an average width of nearly three miles, is covered with gravel to which enough earthy matter is added to make a soil of unrivaled richness. The gravel of the valley, like that of the Williams Creek bluffs, is mostly of metamorphic origin and much water worn. At some points the gravel beds of the valley reach below the channel of the river, and are consequently more than thirty feet thick, while at Waterloo and above toward the Wayne county line the principal portion of the third terrace bottom is a bed of blue clay covered with a gravel soil. The alluvium of the first terrace is enriched by frequent overflows that are said to reach the second bottoms once in eight years. The alluvium of the higher terrace must have been deposited by the river when its expanse was much greater than at present.

Bowlders are occasionally found over all parts of the county, but so far as seen by me are most frequent and largest in the west part of Connersville township. No very large ones were seen or reported. Granite, quartzite and greenstone are the most common varieties, and all show the results of erosion.

ECONOMIC GEOLOGY.

AGRICULTURE.

The agricultural resources of Fayette county are practically inexhaustible, yet they may be very much reduced by bad husbandry. The mineral matter essential to vigorous vegetable growth on any kind of land, either black or clay, may fall below that which will produce a paying crop. That there is a deal of bad farming in Indiana every one must admit; the desire to make the most out of the present condition of things, without regard to the future result, is exhausting the farm lands as well as other resources of wealth. The farming of Fayette county is neither better nor worse than that of the adjoining counties; all seem to appreciate the fact that rotation in crops and adaptation of crops to certain soils, with a liberal addition of fertilizers, are necessary to maintain the usual yield of corn, wheat and grass. As already indicated, the yellow clay stratum, together with the underlying blue clay, is not the result of the decomposition of the native stone, but of an origin foreign to the county. Notwithstanding its foreign origin, it is doubtless largely due to the disintegration of rocks, the equivalent of the Fayette county Silurian, and hence has characters more nearly resembling the famous blue grass belt of Kentucky than some other counties of the State. As a corn producing region the black lands have no superior. The mixed or "mulatto" lands produce bountiful crops of wheat, and blue grass flourishes luxuriantly on the broken or

other lands. The farming resources of the county are varied and constitute an unfailing source of wealth; nor are the present citizens likely to permit the high state of cultivation in which they have their farms to depreciate, but rather improve with years and experience.

LIVE STOCK.

Great interest is paid to the growth of cattle, horses, mules, sheep, etc., as might be expected from its luxuriant blue grass pastures. The Hon. W. W. Thrasher, of Fairview, has kept a registered herd of Short Horn cattle for the last forty years. Mr. Ed. Beaver, near Fayetteville, the Munger Brothers, of Bentonville, and the Hon. J. N. Huston, of Connersville, and others, are largely interested in breeding fine cattle. Dairying, as a profitable business, has assumed definite shape in the establishment of the Old Elm Creamery, at Connersville.

FRUITS.

Orchard products are not very abundant, and only hardy varieties seem to succeed tolerably well. One gentleman, living for years in one of the western townships, said to me that he would sue a man for damages who should put out an orchard on his farm; perhaps he had been eating crabs and was a little sour. There is no doubt but in selected localities the apple can be grown profitably. The Maiden Blush is said to be the most productive apple grown, and generally fruits well. Grapes do well; and the abundant crop of May cherries I saw in and around Everton, is evidence to my mind that if the people in that vicinity do not have cherry tarts and pies it is because they are too improvident to plant the trees.

MANUFACTORIES.

The following are some of the leading manufacturing establishments of Connersville: Indiana Furniture Association, bureaus, bedsteads and wash stands; Connersville Furniture M'f'g. Co.; Munk & Roberts, M'f'g. Co.; Cooley Morrison M'f'g. Association; all the above are engaged in manufacturing furniture, and employ about eight hundred hands. P. H. & F. M. Roots, foundry and manufacturers of Roots' Rotary Blower. McFarlan & Sons, carriage shop, work seventy-five men. Western Hosiery Mills employ about one hundred and fifty girls. Two large flouring mills and a hominy mill.

OTHER RESOURCES.

Sand for plastering and building purposes is abundant. If lime is burned in the county I did not hear of it. There are several tile factories and clay for brick and tile is found in almost any neighborhood. The building stone has already been discussed under the head of Local Geology.

The county has two excellent papers, *The Connersville Times*, Republican, Mr. Sinks editor and proprietor, and the *Examiner*, Democratic, Mr. Higgs, editor.

TIMBER.

Much still remains of the heavy timber that formerly grew over all parts of the county. Beech, is perhaps, the most common; oak, ash and elm are not infrequent, and maple and hickory abundant in certain localities. Yellow poplar (*Liriodendron tulipifera*), a species of timber that likes a dry soil, once grew in great profusion on the high land east of Glenwood. A famous grove of yellow poplar formerly existed on the west line of Connersville township, one mile wide and six miles long.

BEES AND FISH.

Mr. Dan. Wurth, of Fairview, and Mr. Jonas Schall, have demonstrated that the bee business can be made a financial success as an exclusive occupation. Efforts are being made, with great promise of success, to grow the German carp fish in artificial ponds, by Mr. Jasper N. Davis, Jr., Mr. Charles Brown, Mr. Thomas Brown, and Mr. Matt. Lair.

ARCHÆOLOGY.

Indian mounds, so called, are not infrequently met with, but none came under my immediate notice. From reports they seem to have been all small. Relics are common, and Mr. Milton Trussler, who resides near Everton, is said to have one of the finest collections in the State; on account of the death of his mother-in-law at the time I was in that vicinity, I was prevented from seeing his cabinet.

THANKS.

Acknowledgments are due all the citizens of the county that I met, and especially to Hon. W. W. Thrasher, of Fairview; Hon. W. H. Boadus, of Harrisburg; Hon. J. N. Huston and Mr. Sinks, of Connersville; Mr. John Benedict, of Longwood; Mr. Jasper N. Davis, of Connersville township; Mr. Thomas Ochiltree, of Glenwood; Mr. Jos. Ramsey, Jr., Civil Engineer of Cincinnati, Hamilton & Dayton R. R; Mr. R. L. Read, Civil Engineer of White Water R. R., and especially to the kindness of Prof. E. A. Allen, of Rising Sun, who accompanied me while doing field work, and for valuable suggestions, etc.

GEOLOGICAL AND TOPOGRAPHICAL SURVEY

OF

UNION COUNTY, INDIANA.

BY MOSES N. ELROD, M. D.

1884.

HISTORICAL AND DESCRIPTIVE.

Union county is a small county, but the energy and intelligence of its people make up for any lack of territory. With $691 as its *per capita* valuation of taxable wealth, it has for years lead every other county in the State.

The boundaries of the county are: Wayne county, on the north; Preble and Butler counties, Ohio, on the east; Franklin county, on the south, and Fayette county on the west.

It is twelve miles wide, east and west, by fourteen miles in length, north and south, comprising 168 square miles; 104,346 acres of land appraised for taxation, and 21,571 not reported. In 1883 the total value of taxables was $5,325,365; value of lands, $2,877,755; value of improvements within the year, $435,875; value of town lots, $92,790; value of town improvements for the year, $169,050; value of personal property, including telegraphs and railroads, $1,749,895.

The old Indian boundary line, established in 1798 by Israel Ludlow, in accordance with the treaty made with the aborigines at Greenville, August 3, 1795, ran from Fort Recovery, Ohio, to the Ohio River opposite the mouth of the Kentucky River, dividing the county into nearly equal parts. West of this treaty line, the remainder of the county was opened to settlement by the "Twelve Miles Purchase," or treaty of General Harrison, made at Fort Wayne, September 30, 1809. The work of the Government surveyors was completed east of the Greenville treaty line May 14, 1805, and west of the line in the fall and winter of 1810.

At the date of its erection into a separate county, in 1821, Brownsville was the county seat, but it was removed to Liberty in 1823.

Liberty is an attractive town of 1,600 inhabitants, situated on a plateau of land one hundred feet or more above the bed of Silver Creek. It is seventy-one miles southeast of Indianapolis, on the C., H. & I. Railroad,

and fifty-two miles northwest of Cincinnati. Its manufacturing interests are extensive and rapidly improving. The Reede Brothers, manufacturers of corn and wheat drills, employ seventy-five hands, besides other interests in the way of carriage shops, flouring mills, etc. Perhaps no other town of its size in the State presents a more metropolitan character in the way of wholesale and retail business establishments.

Brownsville is a thriving town of 500 inhabitants, on the east bank of East White Water River, and once was a rival claimant with Liberty for the honor and business advantages of the county seat. Dunlapsville is a village of 200 inhabitants, situated on the west bank of White Water, in Liberty township. The White Water Presbyterian Academy, a fine brick structure, was located here, but has been turned over to the township authorities for common school purposes. College Corner is a pretty town in a beautiful country, built up on both sides of the Indiana and Ohio boundary line. Philomath, Hopeville and Clifton, in Brownsville township; Beechy Mire, in Harrison township; Goodwin's Corner, Lotus and Cottage Grove, in Centre township; Billingsville, in Union township; Roseburg, in Liberty township, and Quakertown, in Harmony township, are small neighborhood villages and post offices. Brownsville, Liberty, Lotus and Cottage Grove are on the C., H. & I. Railroad.

The Cincinnati, Hamilton & Indianapolis Railroad, a division of the C., H. & D. system, running from east to west, is the only railroad in the county, but as the county is small there is no apparent need for another road, unless it be as a competing line.

The principal pikes and gravel roads are the Liberty and College Corner, Liberty and Roseburg, Liberty and Richmond, Liberty and Connersville, Liberty, Boston and Richmond, Liberty and Camden, Liberty and Brownsville, and the College Corner and Western. The ordinary roads throughout the county are good and kept in repair by the constant addition of gravel. The present system of repairs will in time make gravel roads of all the leading thoroughfares. Good roads enhance the value of the land through which they pass at least ten per cent. An old resident of an adjoining county told me that the land on the pikes in his vicinity was worth ten dollars an acre more than land of equal fertility located on the mud roads. It is short-sighted economy, the great size of the nickel in hand compared with the one in prospect, that keeps the people from having good roads everywhere.

TOPOGRAPHY AND DRAINAGE.

The rocky bed of Union county, underlying the earthy deposit, is probably wholly made up of Lower Silurian rocks, and as there is satisfactory geological evidence that the top of the early Lower Silurian upheaval of Indiana and Ohio was primarily a broad expanse of level country from

the western side of Fayette county, Indiana, to Greene and Clinton counties, Ohio, it follows that the present inequalities of the surface along the course of East White Water River and its confluents are the results of erosion and denudation. So slight is the difference in the elevation of the western and eastern sides of this ancient geological island of old ocean that the nicest measurements are necessary to demonstrate it.

The East Fork of White Water River flows through the central part of Brownsville, Liberty and Harmony townships, and as the excavation of the river bed and valley has been in proportion to the supply of water the bluff banks are higher here than on the creeks. In the vicinity of the river the bluffs reach an altitude of 200 feet and over above the bottom of the stream. It seems probable that in the early geological history of the Lower Silurian, when the stone was less resistant than at present, the water courses excavated channels like those of the famous canyons of the West, but their much greater geological age has given time for the action of forces that have extended the width of the channel to that of a valley without increasing the depth, and rounded off the rough and precipitous contours. Yet the river and creek bluffs are in places bold and present rocky fronts. The valleys are narrow but fertile. The upland is level and most admirably adapted to agricultural pursuits. The west part of the county is broken by the river and creek bluffs, the eastern townships, Harrison, Centre and Union, level. The vast body of the land of the county can be cultivated.

The main tributary creeks of East White Water are Simpson's and Eli's Creeks on the west, and Silver and Hannah's Creeks on the east. The creeks on the west side of the river have their origin on the divide between the East and West Forks of White Water, and are consequently short in their course and small, while those on the east side are longer and carry a greater volume of water.

Elevations taken on the Cincinnati, Hamilton & Indianapolis Railroad.

Miles from Indianapolis	POINTS AT WHICH THE ELEVATIONS ARE TAKEN.	Feet above Ocean.
	Indianapolis, Union Depot	721
57.1	Connersville	844
	Simpson's Creek, natural surface	794
	East Fork of White Water bridge	802
	East Fork of White Water River, natural surface	773
65.3	Brownsville, grade line	806
	Richmond Creek bridge	818
	Richmond Creek, natural surface	777
	Arlington pike	886
	Liberty and Brownsville pike	986
	Silver Creek bridge	962
	Silver Creek, natural surface	890
71.4	Liberty, grade line	992
	Summit, natural surface	1,042
	Hannah Creek bridge	991
	Hannah Creek, natural surface	945
74.3	Lotus, grade line	1,055
	Summit, natural surface	1,090
	Little Indian Creek, natural surface	1,019
76.5	Cottage Grove, grade line	1,054
	Big Indian Creek, natural surface	1,019
79.4	College Corner, grade line	1,002
	State line, natural surface	998
	Hamilton, Ohio, grade line	839

GENERAL GEOLOGY.

From a pretty thorough examination of the rocky outcrops on the East Fork of White Water River and its tributaries in Union county, I feel convinced that the top members of the Hudson River group of the Lower Silurian division of the Silurian Age, are the only portions of that Age to be seen. That the Upper Silurian may be found on the verv highest points I am not prepared to deny, but such outcrops will be found to be wholly exceptional to the general rule.

An ideal section, based on numerous measurements of the stone exposed to view, at various places, including the black soil, river deposits, clay and gravel, given below, shows the general average for the county:

GENERAL SECTION OF UNION COUNTY.

QUATERNARY AGE, OR AGE OF MAN.

RECENT PERIOD—	
Alluvium, black soil, river and creek deposits	10 ft.
DRIFT PERIOD—	
Yellow clay, blue clay, sand and bowlders	50 ft.
Silurian Age, Lower Silurian Division, Hudson River Period, alternating strata of limestone and marl or shale in beds ranging from one inch to two feet in thickness, the stony portions highly fossiliferous	230 ft.
Total	290 ft.

The reader, by comparing the above with a general geological section of the earth's crust, as that in Webster's Unabridged Dictionary, will see that only a part of the lower portion of the sedimentary and fossiliferous rocks are represented, and that all the long ages and masses of stone found at various places over the face of the globe are here wanting. The Lower Silurian rocks of Indiana and Ohio were elevated above the influences of the ocean at or about the time of the genesis of the oldest mountains of the East and the mountains of Missouri, and were probably dry land from that day to the Drift Period.

The rocky portion of Hudson River group stone in Union county is largely composed of the remains of animal life that were entombed in the mud of an ancient ocean. The marl or clay partings near the top of the outcrops are frequently fossiliferous, but as a rule they are devoid of organic remains. The section hereafter given of Mr. Farley's quarry at Liberty shows the ratio of marl to stone, excluding the shale beds that could not be separated into its component parts, as 5.75 to 9, but if all the marly portions are included the proportion of marl to stone will be increased. It will be found that the nearer the top of Hudson River group the quarry is opened the greater the per centage of stone and the heavier the bedding. It follows from this, that aside from the expense of stripping, the best quarries can be opened near the top of the highest bluffs. The bedding is tolerably even, and a single stratum may be followed for several feet, but shows more tendency to run out, change to marl or split into a number of strata, than the Niagara group limestone. Vertical seams are common, hence long slabs or flags are not readily found. The existence of vertical seams explains why no overhanging rocks are seen on the bluffs; as soon as the stone is undermined by the wasting of the clay partings the stone falls for want of lateral support. And yet it is a singular fact that no fragments of stone or talus are seen at the foot of the most precipitious banks; nor are they found in the over-

lying clay. The eastern face of the bluffs west of Brownsville, near the railroad bridge, shows an earthy deposit nearly to the top with a very few loose slabs on the surface; the same fact is illustrated in the vicinity of Liberty and at Dunlapsville. The clay and soil seems to have accumulated in the same ratio that the bluff has receded; the detached fragments of stone have crumbled to mother earth and replaced the constantly wasting soil.

LIST OF HUDSON RIVER GROUP FOSSILS, MOST COMMONLY FOUND IN UNION COUNTY.

Streptelasma corniculum	Hall.
Monticulipora rugosa	Edwards & Haime.
Monticulipora pulchellus	Edwards & Haime.
Monticulipora mammillata	d'Orbigny.
Monticulipora dalii	Edwards & Haime.
Zygospira modesta	Say.
Rhynchonella ventricosa	Hall.
Rhynchonella capax	Conrad.
Strophomena alternata	Conrad.
Strophomena planoconvexa	Hall.
Strophomena nasuta	Conrad.
Strophomena tenuistriata	Sowerby.
Orthis occidentalis	Hall.
Orthis biforata var. *Lynx*	Eichwald.
Orthis subquadrata	Hall.
Orthis sinuata	Hall.
Orthis testudinaria	Dalman.
Tentaculites richmondensis	Miller.
Bellerophon bilobatus	Sowerby.
Ambonychia costata	James.
Orthodesma recturn	H. & W.
Modiolopsis planorbiformis	Hall.
Pleurotomaria, 2 sp. (?)	
Orthoceras, 3 sp. (?)	
Calymene senaria	Conrad.
Asaphus gigas	DeKay.

In the branch or ravine one-quarter of a mile southeast of the Brownsville railroad station is a famous locality for finding trilobites of the *Calymene senaria* species. The specimens are imbedded in a stratum of soft, blue clay that is probably one hundred feet below the top of the Hudson River group. An equivalent bed outcrops in the southwest part of Liberty. The specimens from these beds are perfect, and require no other cleaning than the vigorous use of a stiff brush before the specimen

becomes dry. Other remains found in these beds are in an equally good state of preservation. The postmaster and a number of other persons in the town have good trilobites. And I here wish to enter my protest against people thinking that if a visitor does not want to buy everything they exhibit, he has no interest in finding out the geology of a neighborhood, and that stories about what some man in Philadelphia would give for a trilobite has nothing to do with my business. Collectors visiting Brownsville had best seek their own specimens if they want to save money. The fancy price paid by a drummer does not govern the market. Not that I wanted to buy, but that parties failed to show their collections when satisfied that I was not on a begging or buying expedition. Scientists should never encourage persons who simply collect for the money there is in what they find, especially if a man grown to the years of maturity; they are invariably guerillas and bummers, that expect to fleece the unwary, and should be promptly and severely let alone. From what little time I had for collecting in the quarries at Liberty and on Hannah's Creek, I can promise collectors that they will find fine cabinet specimens in those localities, and especially in the marly partings of Mr. Farley's quarry.

LOCAL DETAILS.

HUDSON RIVER PERIOD.

Section at Patrick Shirkey's Quarry.

Section 6, Town. 12 N., R. 14 E. 2d principal meridian.

Rubble, Hudson River period	2 ft.	0 in.
Blue stone		4 in.
Blue stone		4 in.
Blue clay or marl		5 in.
Blue limestone quarry		4 in.
Blue clay		2 in.
Blue limestone		4 in.
Blue limestone		4 in.
Clouded limestone		6 in.
Clouded limestone		2 in.
Blue limestone		2 in.
Dimension stone		10 in.
Dimension stone		4 in.
Total	6 ft.	5 in.

Mr. Shirkey's quarry is on a little creek that comes down from near Philomath, and is opened near the top of the Hudson River group stone. The percentage of stone to marl is larger than at many other places, and

on the creek in that vicinity other quarries can be opened and worked for some years to supply the local demand at a small expense. The quality of the stone is above that of the average Lower Silurian rock. East of Mr. Shirkey's, section 22, town. 12 north, range 2 west of 1st principal meridian, between Hopeville and Clifton, are some quarries opened on the high bluffs that have considerable local reputation for furnishing good stone for ordinary building purposes.

Section on the Bluff west of the Brownsville Railroad Bridge.

Soil and yellow clay	4 ft.	0 in.
Ochery-colored limestone		4 in.
Marl		2 in.
Limestone		6 in.
Marl		1 in.
Limestone		7 in.
Limestone		3 in.
Marl		3 in.
Limestone		6 in.
Marl		2 in.
Limestone		3 in.
Limestone		2 in.
Marl		1 in.
Limestone and marl in strata ranging from 2 to 8 inches thick	5 ft.	10 in.
Total	13 ft.	2 in.

I climbed the steep bluff at this place, hoping to find an outcrop of the Niagara or Clinton groups, but was disappointed. The stone quarried shows fair slabs that are highly fossiliferous, and has been used in building the abutments of nearly all the bridges. One thing at least can be said for the economical working of the quarry—the ease with which the product can be moved down the face of the precipitous bluff.

Section at Mr. P. Farley's Quarry, near Silver Creek, Liberty, Ind.

Soil, clay and gravel	10 ft.	00 in.
Shale, Hudson River group	4 ft.	00 in.
Limestone, flag		2 in.
Limestone, flag		3 in.
Marl		6 in.
Flag		2 in.
Marl		1 in.
Flag		2 in.
Marl		1 in.
Flag		2 in.
Marl		3 in.
Limestone, quarry stone		3 in.
Limestone, quarry stone		3 in.

Limestone, quarry stone		4 in.
Marl		3 in.
Limestone, flag		4 in.
Shale	1 ft.	3 in.
Limestone, good quarry stone		8 in.
Marl and shale	2 ft.	00 in.
Limestone, good quarry stone		5 in.
Marl and shale	2 ft.	00 in.
Limestone, quarry stone		4 in.
Limestone, good quarry stone		5 in.
Shale and stone	3 ft.	6 in.
Limestone, quarry stone		3 in.
Marl		2 in.
Limestone, quarry stone		3 in.
Limestone, quarry stone		4 in.
Marl		4 in.
Limestone		2 in.
Limestone		2 in.
Marl		6 in.
Limestone, good quarry stone		6 in.
Marl		1 in.
Limestone, quarry stone		4 in.
Marl		2 in.
Limestone, good quarry stone		5 in.
Marl		2 in.
Limestone, good quarry stone		4 in.
Marl and shale	1 ft.	5 in.
Limestone, good quarry stone		6 in.
Total	43 ft.	11 in.

This quarry is opened in the bluff bank on the east side of the creek and the northwest part of the town. Quite an amount of quarrying has been done and considering the per cent. of waste coming from the shale and marl beds the dump is not large. In the main the limestone ledges are all fair Lower Silurian stone that meets a demand for stone in light structures.

The quarry of Mr. W. H. Stevens, southwest of town, shows the same or a similar quality of stone to that given above. The local advantages of a few inches more or less in the thickness of the strata of quarry stone compared with the marl and shale change within a few feet, so that sections might be taken every 100 feet that differ in the general result nearly as much as that of sections taken one mile apart, hence it is not necessary to repeat them here.

I again wish to call the attention of geological collectors to the specimens to be found in the marly parting and shale in the vicinity of Liberty. The trilobite bed in the blue clay below town is the equivalent horizon of the Brownsville bed, and in both places they are about 100 feet below the top of the bluffs.

The quality of the limestone of Union county is equal to that of the Lower Silurian at other places. In a general way the bedding may be said to be even throughout the extent of the quarry. In color it is not uniform, but is almost universally known as the *blue limestone.* Exposure to the surface, by permitting the action of the oxygen of the atmosphere on the contained protoxide of iron converting it into a higher oxide causes a change of color from blue to a yellowish or light blue.

The semi-crystalline structure of the stone and its high per cent. of calcium carbonate renders it peculiarly valuable for burning to lime. It makes a medium "hot" or strong lime.

In a general way it is not as valuable for building purposes as the Niagara, because of a want of uniformity in structure, the result of its fossiliferous character. The best building stone found in the State is either free from or nearly devoid of organic remains.

QUATERNARY AGE.

RECENT AND DRIFT PERIOD.

The Drift deposits of the county, that are everywhere present on the high lands, are the two divisions of the overlying yellow clay and the underlying blue clay, or hardpan. They are both of foreign origin. In the valleys are found clay, gravel and sand beds that are the result of forces now acting, changing and re-arranging the materials of the Drift Period, to which is constantly being added the waste from the native stone.

On the high lands the Drift deposits reach a thickness of one hundred feet, in places, but as a rule will not average over forty feet. The yellow clay stratum or subsoil of the uplands will average about fifteen feet. A well on the pike from Liberty to College Corner gave the following:

Section of D. W. Moore's Well, two miles west of College Corner.

Soil	2 ft.	00 in.
Yellow clay	30 ft.	00 in.
Blue clay	20 ft.	00 in.
Water in the sand	00 ft.	00 in.
Total	52 ft.	00 in.

The thickness of the yellow clay in this well is exceptional. But little clean gravel occurs on the uplands, and bowlders are infrequent, but an occasional mass of stone, granite, greenstone or quartzite is met with on the East Fork of White Water River and the creeks, measuring two or three feet in diameter. On the bluff east of Brownsville, water-worn and polished fragments of stone were seen showing one surface highly polished

and the other rough as if just detached from its native bedding. Without any intention to indicate a theory as to the origin of these stones, further than that they are not native to Union county, but once had their home in the North, probably north of the Great Lakes, I wish to call attention to the fact that the polishing on some of them is equal to that of the work done in the marble yards of to-day, and certainly can not be the result of one stone grinding promiscuously over the native rocks, but rather the result of the effect of passing over a soft clay bed. Identical specimens were seen on Big Williams Creek, in Fayette county.

The native soils formed *in situ* from the decomposition of the blue limestone rocks, are confined to the blnffs, river and creek bottoms, and together with the black soil of the high lands, are the only representatives of the Recent Period found in the county. Compared with the Drift soil they are very limited in extent; but as a covering to the Drift clays, especially the yellow clay that constitutes the sub-soil of the uplands, the black soil, in its general diffusion over the surface of the county, is the basis of unbounded wealth. Possessed of great fertility, the black soils, including the yellow clay lands that have for years been enriched by the accumulation of *humus* from decaying vegetation, produce year after year the most exhausting crops without deterioration.

ECONOMIC GEOLOGY.

AGRICULTURE.

The unrivaled resources of Union county, as shown in the *per capita* wealth of its inhabitants, is largely due to the more than average wealth of its farmers. Except the rocky faces of the precipitous bluffs that may be striking in appearance, but are unimportant in area, every foot of the county is available for farming purposes or pasture. No finer or more productive land than that of the high lands and the river bottoms can be found, and from the fine residences that are seen on the highways and byways, the visitor is more than impressed with the thrift and wealth of the people.

A dense forest of burr oak (*Quercus macrocarpa*), swamp white oak (*Quercus discolor*), swamp Spanish oak (*Quercus palustris*), beech (*Fagus feruginea*) and American elm (*Ulmus americana*), were most commonly found on the wet or black soil of the county. On the dryer portions of the land, sugar maple (*Acer saccharinum*), black walnut (*Juglans nigra*), and yellow poplar (*Liriodendron tulipifera*), were frequent, and an occasional fine specimen is to be seen at this day.

OTHER RESOURCES.

Sand for plastering and masonry work is abundant on the creeks. Gravel for road making is also found on the creeks, and especially in the bottoms of White Water River. Clay for making brick and tile can be

had at all points wherever it is desired to erect a kiln or factory. Orchard products are not very abundant and apples do not seem to do well, but pears, according to a recent report of the Indiana Horticultural Society, are more than an average success. It seems to the writer that pears are a success in all parts of Indiana south of Indianapolis. The famous old pear tree of Vincennes is proof that the climate is favorable, and that soils adapted to its growth can be found on any farm is self-evident to the most casual observer.

INDIAN MOUNDS.

Ancient mounds were reported as found on the farms of John F. Bell, Jacob Keller and D. T. Harvey, in Brownsville township. None of them are peculiar, other than that they are the burial places of an extinct race. Relics are common, or rather were common, in all parts of the county.

THANKS.

I am under obligations for favors to all the people of Union county that it was my fortune to meet. And especially am I indebted for favors to Professor E. A. Allen, of Rising Sun, Indiana, who accompanied me while in the field; to the Chief Engineer, civil, of the C., H. & I. Railroad, and to my wife and daughter, who have helped me to put my manuscript in shape for the printer.

UNIVERSITY CAVE.

GREENCASTLE, PUTNAM COUNTY.

But recently, October, 1884, attention has been called to the existence of a cave in the St. Louis limestone, a member of the Lower Carboniferous period. This limestone is noted in the United States for the readiness with which it weathers into subterranean caves. This peculiar feature has given to this formation the familiar name of "cavernous" or "sink-hole" limestone. It is in this rock that the famous Mammoth Cave of Kentucky, and the still more beautiful and extensive Wyandotte Cave of Crawford county, Indiana, are found. The extent of these subterranean caverns, the magnitude of their halls, and the many fantastic forms into which the rocks have been wrought by the decomposing action of water, and the beauty of their calcic formations, have given them a world-wide reputation. The Mammoth Cave was the earliest explored and advertised, and pæans in its praise were sung long before its great rival, the Wyandotte, had been brought to public notice. From this cause, alone, has it held an unmerited supremacy as the grandest grotto known to the world. Since the time when saltpeter was made in this cave, to supply the want of the foreign article in the manufacture of gunpowder, to be used in defense of the country in the war of 1812, it has been the one great object of home and foreign travelers, and it has been long held that the two grandest natural curiosities of America are the Niagara Falls and the Mammoth Cave. The great naturalist, C. A. Leseure, used to add a third, the "Rattle Snake," for the rattle snake is only known in America.

The Wyandotte is estimated by recent explorers to contain 53 miles of travel, going and returning. The magnitude of its rooms, with their "step-like" domes, have no counterparts in the rooms of other caves. The gorgeous calcic decorations of its halls and galleries for brilliancy and effective imagery are unequaled by the grottoes of the fabled Genie. Had America been inhabited by a race of Troglodytes they could have found homes in the cavernous limestone of Indiana, and become a populous race, but like the *Amblyopsis* and other denizens of the caves, become non-seeing.

Innumerable small caves are found in Harrison, Lawrence and Monroe counties, Indiana. In Orange county a large tributary of White River has worn its way through the St. Louis limestone, and from a living stream passes beneath the surface for many miles before rising and again flowing over the surface. This feature has given to it the name of "Lost River."

"University Cave," at Greencastle, is quite small, and so far as known is not characterized by extensive calcic ornaments, but, nevertheless, is of geological and general interest and is worthy of further exploration.

The following letter was received from John P. Reasoner, who, at my request, made a partial examination of this cave November, 1884.

It is to be hoped that the students of DePauw University will make a thorough search in the earth-covered floor of this cave for the remains of extinct and recent vertebrated animals, and relics of man. The following is Mr. Reasoner's letter:

GREENCASTLE, IND., November 22, 1884.

Hon. John Collett, State Geologist, Indianapolis, Ind.:

DEAR SIR—In accordance with your request that I make an exploration of the cave in the vicinity of Greencastle, I started this morning in company with Prof. De Motte, at 7:20 o'clock A. M. Another gentleman, a Sophomore, also accompanied me. The articles which we took with us were a compass, a bull's eye lantern, candles, matches and an old suit of clothes.

The entrance to the cave, through which we went is situated about 60 feet from the L., N. A. & C. R. R., about 1 mile from the I. & St. L. and L., N. A. & C. depots, and about ½ mile from the stand which Blaine spoke from.

Going down into the entrance, which is about 10 feet from the surface, we went in through an aperture about 2 feet in diameter, and about 5 feet long. After getting through this we were in a place about large enough for one to stand, and putting our hats on a kind of shelf of rock, we went through another hole about 2½ feet high, situated at the bottom of the cavern in which we were standing. After getting through this we were in a room about 20 feet square, and 8 or 10 feet high, from which all the side passages branched, the number branching from this room being four.

We first took one going northeast. It was quite winding, had a good level dirt floor, rock ceiling, and was about 4 feet wide and 3½ feet high. We went out for perhaps 150 yards, till we came to a seemingly impassable place, which being about 3 feet from the level of the floor of the cave, wound nearly around and let me into a large cavern 20 or 22 feet long, 9 or 10 feet high, and 5 or 6 feet wide. The winding entrance to which

I gained access to this was nearly round, about $1\frac{3}{4}$ feet in diameter, and in getting through this I sprained my shoulder. The large cavern into which I came, wound around and finally came to an end, except at the bottom, on a level with the floor, a small aperture 2 feet high, through which I was unable to get, but, with the aid of my "bull's eye" lantern I saw that there was a still larger cavern, which, were the entrance blasted out, would probably lead up town.

Retracing our steps we came back to the first room, from which, as I said before, the passages branched off. My associate would go no farther on account of the winding path of the cave, and the number of side passages branching off, thus making it easy to get lost in such a labyrinth.

I tied the ball of twine to the post at the entrance and let it out. This passage was larger than the first, and on account of the dripping of the water from the stalactites, was much more muddy, for a few hundred feet, but after a little time it became dry. The average height of this passage is $4\frac{1}{2}$ feet; width, 3 feet; that is, the first part, but the last is much larger. I came to the end of the ball of twine near what seemed to be the end of the passage, and upon the wall some one's name, very indistinct, bearing the date of 1830, or some date like it. It is very indistinct. There are many other names of former students of the University. Peering around I found a small entrance about one and a half feet high, and very narrow, through which I went, and continued on until my second ball of twine was exhausted, and still on after that to the extent of what I judged to be the length of another ball. The train passed over me and I could hear the rocks jar overhead. It is truly wonderful how far one can hear in it, as I went around several right-angles and still could hear a "hallo" from nearly the entrance.

I had gone about as far as I cared about without anything to guide me, so I turned back. I got a piece of detached rock and some dirt from the farthest place I was in. I almost forgot to mention that at the end of the first passage we found debris of stems of trees and mud all over the walls, as if it had at one time been a subterranean stream. I send you samples of all of these, together with a few small stalactites, which I was able to knock off with the means at hand.

Coming back I saw a small entrance, and I went in and found it to be 20 or 30 feet across and 9 feet high, with a mound similar to an Indian mound in the centre of it, covered with stones and rocks. Pursuing my way toward the entrance I procured several stalactites and made my exit. Were the cave to be thoroughly explored, I have no doubt many interesting things would come to light.

The average temperature I should judge to be 15 or 20 degrees above the outside air.

John P. Reasoner.

INDIANA OOLITIC LIMESTONE.

The following table of tests, with explanatory formulas, made by a distinguished architect of New York City, is given for information of builders, engineers and purchasers. The table of breakages will apply closely to the other Oolitic Limestones of Indiana, and shows the usual superiority over sandstone of from about ten to thirty per cent. Builders should not neglect this strong, cheap, durable material.

JOHN COLLETT, *State Geologist.*

A TABLE

Exhibiting the Comparative Strength of several varieties of Sandstone in common use for Building Purposes as compared with Salem (Oolitic) Stone, from Salem, Washington County, Indiana, showing the great superiority of Salem Stone over all other Stones named.

The Tests were made by R. S. HATFIELD, Architect, 31 Pine Street, New York City.

In the formula, $S = \frac{lw}{bd2}$, l is in feet and b and d are in inches, while w is in pounds. Hence S is the weight in pounds required to break a bar one inch square and one foot long in the clear between the bearings. In the third column of the table the lengths of the specimens tested are stated in inches; the breadths and depths are also in inches, and the breaking weights in pounds.

NAME.	LOCATION.	Length. Inches.	Breadth. Inches.	Depth. Inches.	Breaking Weight. Lbs.	$S = \frac{lw}{bd2}$ See Note.*
Oolitic Limestone . .	Salem, Indiana. . .	13.	2.02	1.98	747.	93.949
" " . .	" " . . .	13.	2.02	2.03	771.	92.621
" " . .	" " . . .	13.	2.02	2.01	788.	96.557
" " . .	" " . . .	13.	1.98	2.00	809.	102.146
" " . .	" " . . .	13.	2.03	2.00	788.	97.044
" " . .	" " . . .	13.	2.02	1.98	745.	94.075
Sandstone	Amherst, Ohio . . .	5.	3.25	1.22	389.	32.506
"	" " . . .	14.	1.47	3.05	395.	33.700
"	" " . . .	3.	3.45	1.06	536.	34.568
"	" " . . .	14.	1.47	3.05	410.	34.980
"	" " . . .	14.	1.45	3.07	436.	37.221
"	Berea, " . . .	4.	1.63	1.03	200.	38.552
"	" " . . .	4.5	1.97	1.01	227.	42.359
"	Marietta, " . . .	6.	1.43	1.58	401.	56.165
"	" " . .	6.	2.05	1.25	395.	61.659
"	" " . . .	6.	2.03	.97	240.	62.826
"	Dorchester, N. S . .	14.	1.45	3.16	786.	63.333
"	" " . .	14.	1.43	3.15	781.	64.216
"	" " . .	14.	1.45	3.10	780.	66.980
"	Portland, Conn. . .	14.	1.35	2.98	665.	64.715
"	" " . .	14.	1.38	2.97	761.	72.936
"	Belleville, N. J. . .	14.	1.50	2.97	862.	76.006
"	" " . .	14.	1.50	2.97	1000.	88.174
"	" " . .	14.	1.48	2.97	990.	88.472

* NOTE.—Weight required to break a bar one inch square and one foot long in the clear between bearings.

FISH CULTURE IN INDIANA.

BY RYLAND T. BROWN, A. M., M. D.

The high price of animal food in the four standard forms in this country, to-wit: beef, pork, mutton and poultry, invites an inquiry into the possibility of some cheaper supply for this demand. Philanthropists have proposed to solve this problem by diminishing the demand rather than by increasing the supply. But in this latitude this will hardly be possible. I do not mean to say that a vegetarian might not live and enjoy good health, and even endure labor without the luxury of animal food, but my doubt is whether he could be induced to do so voluntarily.

The cool, bracing air of the winter months, and a good part of the fall and spring months, as well, tend to hasten the transformation of the living tissues, and this creates an instinctive demand for concentrated forms of food, and this demand few will be heedless of except from necessity. Even the savage in all countries and in all ages, when the chase fails to supply him with food, resorts to the waters to make good the deficiency, and may not our civilization profit by the hint?

As an apology for their neglect of this matter, our people plead their want of knowledge on almost every subject connected with fish culture. This may be the case but it is no excuse for their remaining in ignorance of a profitable branch of business. It is asserted on good authority that more pounds of wholesome food can be produced, in a given time, from one acre of a well-stocked pond than can be made in beef or pork from ten acres, and with much less labor or risk.

The first consideration is to determine what kind of fish you will raise. Our streams are well stocked with native species of fish, many of which will bear domestication well. A few of our native fishes are migratory, going south at least as far as the great rivers every winter. These will not well endure the confinement of a pond. The Sucker family (*Catostomi*) furnish several species, many of which are stationary and easily domesticated. The flesh is of fair quality but is objectionable on account of the great number of small bones it contains. The Catfish family (*Silurus*) presents two or three native species that may be raised in ponds with only a poor supply of running water, but their flesh is not generally esteemed

as first quality. The yellow cat is the best species of this genus, but it is of a smaller growth than others of the family. Where a pond has no supply of running water, the yellow catfish may be profitably raised. The Bass family (*Labrax*) furnish the best variety of food of any of our fresh-water fishes. The native black bass of our rivers and the rock bass or red-eyes are the best species for domestication that this family furnishes. Of the Salmon family, the trout species, of which there are a number of varieties, furnish the best pond fish, where the water is adapted to their habits. They are not natives of Indiana, except, perhaps, in some of the small lakes in the extreme north of the State.

Of foreign fishes, the carp (*Cyprinus carpio*) is the only one that has been successfully imported into this conntry. It has been raised in a domestic way for centuries in northern Europe, where it furnishes a large supply of wholesome food at a small expense. It was first introduced here in 1831, by Henry Robison, of Newburg, N. Y. His success in its culture induced others to engage in the business, until its importance became so apparent that the general government has taken steps to promote the industry.

In fish culture it is advisable to keep the different species of fish in separate ponds, if more than one kind be raised. After determining the kind to be raised, the next step will be to adapt the pond to the species selected. If it is proposed to raise bass or trout, the pond should be at least four feet deep and should be well supplied with clear spring water. The bass is exclusively a flesh eater, and though they will find much to gratify this appetite in the insects and worms that may infest the pond, yet they should be fed butchers' offal or some other animal food to prevent them from feeding on their own young, which they are apt to do when pressed by hunger; though a bass at a single spawning will produce from 500 to 1000 young, yet they do not multiply rapidly on account of this cannibal propensity. The trout, though a flesh eater, is less disposed to devour its own young. The bass will guard her nest with the utmost vigilance for six weeks, but after that she has no regard for her young. This class gives us the best of our fresh water fishes, but they are the most difficult to raise. The other class, consisting of suckers, catfish and carp, will thrive in a pond though the water be neither clear nor cold, and they prefer a muddy bottom to one of gravel or rock.

The carp is a vegetarian in its habits, feeding on aquatic herbage and on garden vegetables and fruits or grain when fed to them. They will, however, devour insects or worms when these come in their way, but they never eat the young of their own kind. On this account they multiply with almost incredible rapidity. They grow to the size of eight or ten inches in length in a year, if they are well fed, and they continue their growth till they are three or four years old, and attain a weight of eight or ten pounds.

A carp or cat-fish pond may be supplied from surface drainage, or from the discharge of tile drains. It will be safer, however, to have a well and wind pump to keep a supply of fresh water if no spring be convenient for this purpose. A carp pond will be the better of broad, shallow margins where water grasses and weeds grow, but the centre should have a depth of five or six feet to furnish winter protection for the fish. If the pond be closely covered with ice, and this continues for several days, openings should be made in the ice to the water below, and this should be repeated at intervals of a day or two as long as the freeze continues. If the pond be fed from a spring the point at the entrance of the stream will be kept open and other openings will not be necessary. The general directions for the construction and management of a carp pond will serve for one designed for cat-fish or suckers. Though the cat-fish is to some extent carnivorous in its habits, yet it does not devour its young. It will be better, however, to keep each kind in separate ponds. When kept apart from fishes of prey, they will multiply with astonishing rapidity.

Of all our industries none promises a more profitable return than this much neglected one of fish culture. If market be convenient, it may be made a source of constant income; if not so situated, it may be used to supply the home table, and thus permit more of the beef and pork of the farm to go into the general market.

Something has been done, and much may be done in the way of restocking our streams to increase the supply of fish as an article of food; but when we have done the most, the increased supply is a common stock, a condition which belongs to the savage state of society, and not to an advanced civilization. When fish culture becomes a regular farm industry then the use of fish as an article of daily food will be assured and our tables supplied with a palatable, nutritious and wholesome article of diet at a cheaper rate than we can now furnish any form of animal food.

The ocean and lakes now supplement, to some extent, the "hog and hominy" of the last generation, and this source of supply appears to be inexhaustible.

Professor Huxley, in his address at the late Fisheries Exhibition, said that the great school of codfish which annually moves down the coast of Norway for two months, has a depth of more than 100 feet, and an indefinite width. Each square mile of this school he estimates at 120,000,000 of fishes—enough to supply the city of London with animal food for a year. Similar schools come down the coast of Newfoundland and of British Columbia annually, to say nothing of the immense droves of mackerel, salmon and other marine fishes. Though the fisheries on both continents appear to be very extensive, yet not one in a million of the fish serves as human food, so really inexhaustible is the supply. But the hazard and labor of the fisheries, the loss of quality by salting, or other methods of keeping, together with the expense of transportation, renders it more

economical to raise our own supply and bring them to the table fresh and in good condition.

Ponds can be stocked with our native fishes from the creeks and rivers of the vicinity, with but little trouble; or if carp raising be preferred, the supply for a start may be readily obtained through the State Fish Commissioner, Hon. Calvin Fletcher, Spencer, Owen county, Ind., or at little expense, from private parties who are successfully raising carp in various parts of the country. At any rate, let this important industry be no longer neglected.

How to Prepare and Cook Fish and Other Animal Food.

BY E. T. COX.

While there is such a growing interest manifested in fish culture, it is deemed proper in this connection to add a few words on the subject of preparing and cooking the fish.

It is right and proper for people to know how to procure food material, and it is no less important after it is secured to know how to cook it. "The Angels send food and the Devil sends cooks."

To procure and prepare food are the first steps to be taken to promote animal growth and preserve health. "First catch the rabbit before you cook it," is an old and trite saying.

Dr. R. T. Brown, in his article given above on fish culture, has very truthfully called to our notice the fact that by paying a little attention to the arranging of a suitable pond that the German carp or our Indiana black bass can be raised with as much or greater profit than poultry, and will afford a healthy and pleasing variety of food for the home-table, and a profitable article for market.

The German carp *Cyprinus carpio*, can live in a very small quantity of water. They have been known to do well in ponds so low in water that their dorsal fins remained uncovered, but this is pushing their endurance a little too far. They prefer a warm temperature and a muddy bottom. Therefore, in this rigid climate precaution should be taken to have the pond deep enough to prevent its freezing solid to the bottom, as freezing will kill them. As the carp is largely a vegetarian, the pond should be supplied with aquatic plants, such as *chard* and fresh-water algæ. These can be had in any stagnant water, and readily introduced in the new pond.

These plants are of very rapid growth, and would soon overrun the pond if not kept in check by the feeding of the carp. This aquatic ichthyo-pasture may be advantageously diversified, and the pond rendered more beautiful by the introduction of the white pond lily (*Nymphia odorata*). I do not know that this lily will furnish any food for the fish, but

the beauty and delicious odor of the large white blossoms of this lily give them a ready sale in the market. It is not my object to add more than a passing remark on the able and interesting article of Dr. Brown on the carp and its habitat, but especially to call attention to the mode of preparing the fish for the table. Very few people know how to dress a fish, and fewer still know how to cook it after it has been properly dressed. One of the principal objections brought against the carp is, that it has an *earthy flavor*, derived from its habit of feeding on a muddy bottom. In cleaning a fish the scales should not only be removed, but the skin must be thoroughly scraped to remove the mucous matter. After removing the entrails the cavity should be thoroughly cleaned of all fatty matter and the white, bladder-colored skin, with which it is more or less coated. When thus cleaned place the fish in a moderately strong brine for six to twelve hours. When taken from the salt water, if it be intended to fry the fish, it should be cut into suitable sized pieces, wiped dry, salted, and rolled in corn meal, and then placed in a pan of hot boiling lard and cooked until thoroughly done. Thus cooked the fish will be nicely browned, free from all earthy or fishy flavor, and it forms a dish that the most fastidious epicure would envy.

These remarks are not only applicable to the carp, but to every edible fish.

When fish are to be boiled they need not be cut into pieces or dusted over with corn meal, but they should be wiped dry before being put into the pot. All fish should be served hot.

The State laws for the protection of fish in the streams within its borders are wise and meritorious, and it is to be regretted that they are not better observed, and that violators of the law are not more vigorously prosecuted and brought under its penalty. Part of the trouble may arise from the fact that streams like the Wabash and Ohio Rivers, where they form the boundary between two States, can not be protected from the seines and fish traps of market fishermen, and they are thus encouraged to extend their depredations to the interior waters. If the seines captured only large fish, suitable for the table, it would not be so bad, but they destroy in a wholesale manner small fish that are unfit for sale or use.

It appears, therefore, that in order to more fully protect our river-fish, it is absolutely necessary that Congress should make a law and fix a severe penalty against seining and trapping fish in rivers and lakes that form a boundary between two or more States. Such a law would, I believe, encourage sporting clubs to prosecute violators with a greater assurance of being able to protect and promote the increase of fish to the advantage of all.

While indicating the best manner of preparing and cooking fish, it may not be amiss to say a few words about the cooking of other meats.

There can hardly be a doubt that man in his primitive state was a sav-

age and cannibal of the lowest type, but in the progress of development has, by degrees, but with no great jump (*nihil per saltum*), reached his present high organization and state of civilization. Cannibalism at the present time is confined to a very few isolated savages, in out of the way places; tribes that have been brought into intercourse with the whites have gradually lost all taste for this horrible and revolting custom, but when possible, prefer all kinds of animal food well cooked. The effects of cooked animal diet is made apparent by the civilizing influence which it has exerted on our American Indians. The nomadic tribes eat partly cooked and partly raw meats, while the Pueblo or town Indians, who live a quiet life in communities and cultivate the soil, have their animal food well cooked, and exhibit a marked contrast to their raw flesh-eating relatives and congeners of the chase. The same comparison may be drawn between the wolf and his near cousin, if not immediate descendent, the domestic dog. The latter, carniverous in his primitive state, was a raw flesh eater, but by domestication he has been brought to eat a mixed diet, and that well cooked. When one wishes to make his otherwise peaceable and well behaved dog exhibit a savage and ferocious disposition, he confines him for a few days to a diet of raw meat, and the desired object is most surely attained. Now, as it is with the dog, so it is with man, and I maintain that the growing habit of eating beef and other flesh nearly raw, or but partially cooked, is not only unhealthy, but that it is a pernicious habit—makes man more irritable and petulant and brings out his dormant savage passions, which lead to acts of violence and frequently to murder, and lessens his regard for civil life.

I say that such food is less wholesome than meat which is well cooked; by well cooked, I do not mean that all juices should be dried up and the solid matter cooked to a crisp, but I do maintain that the blood should be coagulated by the cooking, and the parasites which infest all animal food —not alone pork—should be subjected to a cooking process that will destroy their vitality. It is a well known fact that the Abyssinians, who eat raw beef, are the most afflicted with internal parasitic animals of any people on the globe. I am informed that it is an uncommon thing to find one of these people who is totally free from tape-worm—*Tænia solium* and *T. nana.*

It is no argument for one to say that he likes rare beef better than well cooked beef; it is a habit that comes from morbid imaginations and diseased stomachs.

THE DRIFT DEPOSITS OF INDIANA.

BY DR. J. S. NEWBERRY.

Over more than three-fourths of the area of the State of Indiana the surface is occupied by a sheet of clay, gravel, sand and bowlders from 20 to 250 feet in thickness, which covers and generally conceals the underlying rocks. These materials have been transported from localities more or less distant north and east, and have been spread by an agent which has been broad and general in its action, and which is now generally conceded to have been ice. It is also believed that this ice was in the form of glaciers, which at different periods attained different dimensions, but which as a whole formed the characteristic feature of a special epoch in geological history; from this cause denominated the Ice Age.

At this time peculiar climatic conditions prevailed over the whole northern hemisphere, the result of a change which brought down to the line of New York, Cincinnati and St. Louis the present average annual temperature of Greenland, and covered nearly all the surface of this continent north of that line with sheets of perpetual snow. The precipitated moisture in that age, borne from the ocean by essentially the same system of rain-bearing winds as now, instead of flowing off through the great channels of drainage by which it is now returned as fast as it falls, accumulated year after year, so that where the precipitation was greatest the snow fields attained the thickness of thousands of feet. As always occurs under such circumstances, the lower strata of the snow fields were compressed to ice, and this ice, though generally regarded as a solid, possessing a peculiar plasticity, flowed downward from the highlands with a slow but constant motion, much as the same substance in its liquid form flows over a water-shed, eroding, transporting and depositing the materials it encounters, but with a broader and more general action.

As we learn from the already ascertained history of the North American continent in former ages, immediately anterior to that interval which we call the Glacial Period, a mild climate prevailed over all its area, even to the Arctic Sea, and the surface was then covered with a vegetation more luxuriant than that of our Middle States, and was inhabited by a fauna containing more genera and species and with animal forms of larger

size than those which now occupy any portion of the earth's surface. With the approach of the Ice Period the climate of the shores of the polar ocean became gradually colder, the winters longer and more severe, the accumulation of snow greater and greater, century after century, until Arctic conditions prevailed over all North America east of the Missouri and north of Cincinnati and New York, and over the elevated regions of the Far West, down as far as the northern line of New Mexico. In the advance of this great climatic change the snowfall was greatest on the highlands, and the valleys leading down from these were filled with glaciers which descended as ice rivers along the channels excavated by the previously existing water rivers, broadening and deepening these, and scooping out basins in the bordering plains. As the cold became more intense, these local glaciers coalesced into ice sheets which, with lobed margins, over-rode all local topography, planing down projecting points and filling depressions, reaching far out on to the plain country, until in the maximum of cold the limits I have mentioned were reached. During unnumbered ages a great ice sheet or a series of glaciers, coalescing at their sources, moved down from the Canadian highlands, radially southeast, south and southwest, grinding and scoring the rocks over which they passed, and bringing to its margin—the point where it was melted—the debris of all the rocks it had ground up and dislodged in its passage. This transported material formed a terminal moraine at the extreme limit of the ice field, back of which the rocks were scraped bare and in many instances deeply worn away by the grinding action of sand and gravel under the great weight of the moving ice, and striated by the stones which were frozen into and borne forward by it. Probably the increase of cold was not continuous, but the ice fields advanced with many arrests and retreats, as the seasons suffered annual and secular variation. Finally a permanent amelioration of the climate began, and the glaciers retired to the Far North. In this retreat the terminal moraine, left in concentric and constantly diminishing circles around the glacier edge, formed a sheet of debris that covered, in varying thickness, nearly all of the country the ice had occupied, and thus was formed that great accumulation of drift material which is spread over the plain country south of the Canadian highlands, from Newfoundland to the Mississippi, and thence northward, east of the Missouri, to and beyond the British line. This belt is, in places, 500 miles in width, and, although during the long interval which has elapsed since the Drift sheet was spread, it has been constantly eroded by the wash of falling rains, yet it will perhaps now average over all this area, thirty to forty feet in thickness.

The *marginal line* of the Drift sheet in Indiana has been traced with much care by Prof. G. F. Wright from Ohio to Illinois. This line has been sometimes called the line of the terminal moraine, but it is not true that it is marked by any greater accumulation of transported material

than other portions of the Drift area further north. In one sense the whole Drift sheet is a terminal moraine, as it is made up of a collection of contributions of morainic material from the retreating glacier which thus formed a broad sheet by adding concentric lines of contiguous terminal moraines. The margin of the Drift area, as indicated by Prof. Wright, runs from Aurora southwesterly through Ohio and Jefferson counties to Jeffersonville. There it crosses the river and occupies a small portion of Kentucky, as it does opposite Cincinnati. Thence recrossing the Ohio it passes through Clark, Scott, Jackson, Brown and Johnson counties in a northwesterly course to the south line of Morgan county. Here it turns somewhat abruptly and follows a nearly uniform southwesterly course through the counties of Owen, Greene, Knox, Gibson and Posey to New Harmony, where it crosses the Wabash River and enters Illinois. All parts of the State north of this line are covered with Drift deposits, and were once occupied by glaciers. (See Prof. Wright's paper on the *Glacial Boundary in Ohio, Indiana and Kentucky*, page 16, plate 5.)

The *Drift materials* consist, as has been mentioned, of clay, sand, gravel and bowlders. By far the most important of these in thickness and extent is the "till" or bowlder clay, the finer material ground up by the glaciers in their passage over the subjacent rocks, and a characteristic product of glacial erosion in all times and countries. This clay is usually unstratified or irregularly bedded, and is thickly set with smaller or larger fragments of stone, of which the angles are rounded and the sides marked with a peculiar striation, the result of the wear they have received when frozen into the ice and held in contact with hard substances below. From time to time changing their positions in the plastic material in which they wer imbedded, different sides were planed and scratched until they have a tained the characteristic form and markings by which they are everywhere recognized. Where the bowlder clay was spread over an irregular surface, water-basins were sometimes formed from the melting ice, and here the clay was deposited with no pebbles or bowlders—except an occasional one dropped from the floating ice—and was often very regularly stratified.

This bowlder clay is apparently the debris of the softer materials acted upon by the glaciers, limestones, shales, etc., and the softer metamorphic rocks, clay-slate, mica-schist, etc. The feldspars of granites, where they have been worn away, have also contributed to its formation. It is usually calcareous from the limestones that have lain in the path of the glacier.

The mode of formation of the till, or bowlder clay, has been much discussed in Europe and in this country, and a diversity of views has been expressed in regard to it. By most of the European writers on surface geology, both continental and insular, it is supposed to have been formed beneath the glacier, but in the report on the Drift of Ohio, which forms part of Volume II of the Geology of Ohio, I have given evidence which seems to me conclusive that it was formed at the edge of the glacier by

successive contributions made by the retreating and diminishing ice. The planed and scratched surface of the underlying rocks, the sections of fossils, concretions, etc., as well as the fluting of vertical cliffs, prove that the ice was brought into direct contact with the rock, or was separated from it only by a thin layer of sand, which was the cutting agent.

It is impossible that a rock surface should be planed to the smoothness of a house floor, as on the islands in Lake Erie, or grooved and carved with the exactness which many of the ice markings exhibit, by the movement of a mass of gravel, sand and clay pushed forward by the ice. No one can carefully examine the splendid inscriptions made by the ice on Kelley's Islands, Lake Erie, to cite no other examples, without being convinced that during the processes of erosion it was practically in contact with the rock, and that the accumulation of Drift materials above took place at a later date when the ice itself had been withdrawn.

In certain localities we find the stones which were embedded in the bowlder clay crowded together, and with their upper surfaces planed off and striated, forming what are known as *striated pavements.* Here we have proof that the ice sheet, after its retreat, returned and over-rode the moraine it had before formed, and bore it down, much as it had previously done the rocks below. The bowlder clay is remarkably tough and dense, and, where homogeneous, is found to be one of the most difficult materials to remove or excavate. Hence it held the bowlders it contained with great firmness, so that they were quite regularly ground off, without displacement.

In certain localities, however, the returning ice sheet has impinged against the banks of clay it had before piled up, and has with irresistible pressure crushed and crowded them from their former position. These afford examples of what are known as *Contorted Drift,* and such may be seen at various places along the southern border of the lake basins where the great ice mass has been forced against the accumulation of Drift material which covered the southern margins of those basins.

Prof. J. W. Dawson has advanced the theory that the bowlder clay which covers so much of the region about the great lakes was transported and deposited by ice action; suggesting that a depression of the continent at one time permitted the Arctic current which now sweeps the coast to pass into the interior basin, and that icebergs borne by this current not only transported the Drift material, but, dragged over the rock surfaces, produced the planing, furrowing and striation.

I have elsewhere shown, *first,* that the great diversity of level, amounting to over two thousand feet, exhibited by different parts of the margin of the Drift sheet, is incompatible with the theory that this is the water line of a lake or ocean shore; *second,* that the character of the inscription left on the rocks is exactly that of glaciers and not at all such as would be formed by the mere dragging of icebergs over submerged rocks; and

third, that the Drift of the interior basin nowhere contains any of the marine fossils found in the bowlder clay of the Lower St. Lawrence Valley; which would not be the case if the oceanic current had free access to the interior basin. For these reasons, and particularly for the second, which is, as I conceive, demonstrative and conclusive, I can not subscribe to the iceberg theory.

Prof. N. H. Winchell, who has contributed much valuable and important matter to the literature of the Drift, has suggested that the bowlder clay might have been an accumulation of sand, gravel and bowlders occupying the surface of the glacier, and these, with dust blown from the adjacent land area, were left as a continuous sheet upon the melting away of the ice. That such accumulations might take place on the edge of an ice sheet under certain circumstances is highly probable, but it should be remembered that the stones and dirt which gather on the top of local glaciers, such as are conspicuous features of the glaciers of the Alps, can only occur where the glacier is surrounded by higher land, from which dust might blow and rock masses roll; while the broad glaciers which came down from the Canadian highlands were not overlooked by mountain ranges or pierced by pinnacles of rock from which materials of any kind could reach the surface of the ice, but, so far as we can learn, all the area occupied by the ice sheet east of the Hudson was in the maximum of the glacial period like the interior of Greenland, a shoreless sea of ice.

The *sand* which accompanies the bowlder clay sometimes forms lenticular sheets within its substance, sometimes a layer between the clay and the underlying rock, and oftener surface accumulations washed from the clay in later times. This represents the debris of sandstone worn away, or the quartzose material of granites and other crystalline rocks. Sand seems to have been the most potent grinding agent by which the vast erosion of the glaciers was effected. Lying beneath moving masses of ice hundreds and perhaps thousands of feet in thickness, it was pressed down upon the rocks below with such force as to rapidly cut away all materials exposed to its action. With its aid the glacier became a sort of great emery wheel. The soft ice might break off and carry away ledges of rock that opposed its progress, but was, without aid, incapable of grinding down rock surfaces. When the Drift materials are removed from the underlying rocks their broad planed surfaces, sections made of the fossils, pebbles, bowlders and concretions imbedded in the rock, attest the efficiency of ice and sand as eroding agents; while the modulated surfaces, rounded prominences and monotonous topography of the country once occupied by glaciers, prove the amount of erosion effected by the ice sheets to have been enormous. The weight of a cubic foot of ice is about fifty pounds, so that where the ice was a thousand feet in thickness, and we have evidence from its overtopping mountains that it was over large areas many times that, the pressure of 50,000 pounds or more to the square foot must have made its grinding action rapid and irresistible.

The *bowlders* which form in places a conspicuous element in the Drift are of all sizes, and are composed of very diverse materials. Often they lie buried in the bowlder clay or the associated sands and gravels, but most of those which are seen lie upon the surface. These are sometimes of large size, five or ten feet in diameter, and many have been noticed very much larger. The number of bowlders lying scattered over the surface is probably not an accurate measure of their abundance in the Drift deposits below, for many have been left exposed by the washing away of the softer material in which they were imbedded, but conclusive evidence can be gathered at many points that some of these have been dropped where they are found by floating ice. When, as sometimes happens, these bowlders are seen resting upon laminated and bowlderless clay it is evident that they could not have been transported to such points by the water from which the clay was deposited, as water currents do not carry to the same place fine and coarse material. The finer particles, having a much larger ratio of surface to mass than the larger, are transported to a greater distance and deposited by themselves.

In many parts of the Drift area the glaciers in their retreat were bordered by bodies of water over which fragments of ice of greater or less dimensions detached from the ice mass, as they melted, floating or grounded, released the bowlders or pebbles which were imbedded in them and thus scattered them over the bottom of the basin. Such transportation of greater or smaller rock fragments has been noticed by all who have seen icebergs, and it is well known that these are nothing else than masses detached from the margins of glaciers which have flowed down into bodies of water where the difference in the specific gravity of water and ice has caused fragments of the latter to be lifted up and floated away. In the region now occupied by the Great Lakes, it is well known that the retreating glaciers left water basins, of which the ice formed the northern shore, and from time to time floating ice masses were detached from these which carried to different parts of the water basins fragments of rock taken from the country over which the glaciers moved.

The retreat of the great ice sheet which spread the Drift that covers so much of our Northern and Middle States was not uniform, but was marked by many alternations of retreat and advance, as some seasons and cycles of seasons were colder or warmer than others. Some of these alternations were of long duration and have left distinct and unmistakable records. These are styled *interglacial warm periods*, of which several are specified by European geologists, and at least one great one by those who have studied the Drift phenomena of North America. In a great number of localities we have found two bowlder clays, separated by laminated sand and clay; sometimes by beds of peat, with stumps and trunks of trees, which prove that the surface was for a long interval free from ice and partly covered with a growth of vegetation. In Southern Ohio a bed of peat many feet in thickness is found lying between the lower and

upper Drift deposits. In this peat are many trunks and branches of cedar trees, and its surface is covered with a growth of sphagnous moss. There have also been found in it the remains of the giant beaver, which at one time inhabited this country. In many localities not far from this exposure, an old soil with roots and tree trunks has been reached in wells; so that it is evident that here we have proof of a distinct interglacial period, during which the Arctic climate which prevailed before and after was so far ameliorated as to permit the growth over the surface of a vigorous though boreal vegetation. These phenomena I have described in the report on the geological survey of Ohio, and have denominated the sheet of vegetation which is there found in the Drift the *Forest Bed.* Something of the same sort has been noticed in several of the Northern States, including Indiana, and it is evident that this interglacial interval of warmer climate was a distinctly marked epoch in the history of the Ice Period. It should be observed, however, that a part of the accumulation of vegetable matter found beneath the Drift belongs to a time anterior to this, for where "muck beds" and buried timber are met with, as in some places in Indiana, beneath all the Drift deposits, they are probably portions of the old soils and forests that belong to a time anterior to the glacial period, and which in local depressions escaped the denuding action which stripped most of the Drift area of all its superficial material.

The great secular climatic revolution which resulted in the retreat of the glaciers from the fortieth parallel to Greenland was evidently very slow in its progress. Local glaciers in certain localities replaced the great ice sheet, and through ages maintained their flow and did their special work precisely as the local glaciers of the Alps have done in their former extension, and are doing at the present day. In our Western States the retreat of the ice sheet from the plain which bordered the Canadian highlands was accompanied by the formation of a number of local, but still great glaciers, which have left deeply graven and indisputable records of their existence and power. These are the basins of our great lakes, which are broad and deep troughs, for the most part *excavated* in nearly horizontal sedimentary strata. That the lake basins are wholly due to ice action is not claimed; for rivers of ice, like rivers of water, follow the lines of lowest levels, and the surface of our continent was deeply scored by river action long anterior to the Ice Period. As I have elsewhere shown, great rivers traversed the country bordering the Canadian highlands, and received the drainage from this watershed throughout the Tertiary, and probably earlier geological ages.

The valleys of these rivers naturally became the channels through which the glaciers moved when the precipitated moisture held for a time the form of ice, and the effect of glaciers on these river valleys was to expand them into basins such as could not be formed by any flowing

stream. All our chain of Great Lakes, as well as those which extend through the Canadian Dominion to the Arctic Sea, hold a similar and significant relation to the Canadian highlands, from which the great ice sheets and local glaciers descended, and it would probably not be difficult to prove that the entire series is chiefly due to the action of local glaciers which existed during the advance and decadence of the Ice Period.

In various papers of which the titles are given below,* I have discussed the origin of lake basins, and it is not necessary here to review the facts, nor in full the conclusions derived from them. Since the last of these papers was written, the subject has been more fully illustrated, and the conclusions reached confirmed in the "Preliminary Paper on the Terminal Moraine of the Second Glacial Epoch," by Prof. T. C. Chamberlin, Washington, 1883, to which I will refer all those who are interested in pursuing it further. Two of the basins of the Great Lakes bear such relations to the area of Indiana that they should be specially mentioned in this connection. Of these one is Lake Michigan, which cuts into the northwestern corner of the State, and of which the great glacier, fully described by Prof. Chamberlin, contributed something to the Drift deposits that occupy its surface. The other basin is that of Lake Erie, which, though not now extending to the confines of this State, was at one time occupied by a glacier, which, flowing from the east in a general way along the line of its major axis, reached and spread a vast amount of transported material over all the northeastern portion of Indiana.

The islands which occupy the west end of Lake Erie are parts of the Cincinnati arch, an axis of elevation running from Canada to Alabama. They are composed of solid limestone, and like the depressed areas which separate them, every where bear marks of ice action, we may even say, have been carved from the solid rock by this agent. Their surfaces are deeply scored by glacial furrows, and their sides in places beaded like cornices. The furrows run nearly east and west, showing that the motion was in this direction, and that it was from the east westward, is proven by the fact that where masses of chert lie in the limestone these are battered on their eastern sides, and toward the west-southwest are joined to long ridges of limestone which have been protected from erosion by them.

*1. Notes on the Surface Geology of the Basin of the Great Lakes, Proc. Boston Soc. Nat. Hist., Vol. IX, 1862.

2. The Surface Geology of the Basin of the Great Lakes and the Valley of the Mississippi, Annals Lyc. Nat. Hist. New York, Vol. IX, 1869.

3. The Origin of the Great Lakes, Geology of Ohio, Vol. II, p. 72.

4. The Geological History of New York Island and Harbor, Pop. Science Monthly, Vol. XIII, 1878.

5. On the Origin and Drainage of the Great Lakes, Proc. Amer. Philos. Soc., Phil., Nov., 1881, p. 91.

SOURCES OF THE DRIFT DEPOSITS.

Probably much of the material forming the Drift sheet in Indiana has been transported no great distance from its place of origin, and the Drift clays may have been largely derived from the erosion of the sedimentary rocks of the northern portion of the State itself, or from the adjacent States and Canada. This fine material presents no characters by which it can be traced to its source, but the pebbles and bowlders with which it is associated are more suggestive. Among these are representatives of a great variety of crystalline and sedimentary rocks which occur in place in localities more or less remote, northwest, north and northeast from the places where they are found. For example, they include:

1. Masses of native copper and greenstone (diabase) from the copper series of Lake Superior, which prove a movement of the ice and transportation of material from points a little west of north and 400 to 500 miles distant.
2. Fragments of granite, slate and iron ore from the iron region back of Marquette, Michigan.
3. Silicified corals and other Niagara fossils from the country lying just north of the head of Lake Michigan or the islands in Lake Huron.
4. Rolled specimens of *Spirifera mucronata*, a Hamilton fossil from the region directly north of Lake Erie.
5. Fragments of the Water Lime and Corniferous Limestone, with characteristic fossils from the islands of Lake Erie.
6. Hudson River Group rocks and fossils from Canada, north of Lake Ontario.
7. Granite and other crystalline rocks from the Canadian highlands north of Lakes Erie and Ontario.
8. Magnetic iron from the Laurentian series north of Lake Ontario and the St. Lawrence (reported).

The identification of these transported fragments may be accepted as proven from all the localities mentioned above, except the last; but it will be necessary to collect, slice and study under the microscope the fragments of crystalline rocks before they can be exactly located in the districts from which they came. It is to be hoped that some one will interest himself in this promising subject of investigation; for the eruptive and crystalline rocks—all of which are foreign to Indiana, and are largely represented in the Drift material—can, without doubt, be traced directly back to their places of origin.

Confirmatory of the evidence furnished by the Drift bowlders, is that of the glacial striæ. If the sheet of bowlder clay could be lifted from the underlying rocks, they would be generally found to be planed and striated in a peculiar manner, and one that can only be attributed to ice action; but most of this inscribed surface is deeply buried, and therefore invisi-

ble. Where the Drift has been removed, or never permanently rested, the rock surfaces have been exposed to the action of the weather from the Ice Period to the present time; as a consequence, soft rocks, as shales or limestones, which are dissolved by water holding carbonic acid in solution —as all rain water does—have been removed to some extent, and the inscriptions they once bore obliterated.

Hence, it is only in a few localities that natural exposures still retain the glacial markings; and it is not, perhaps, surprising that for lack of this evidence the former presence of glaciers in Indiana has been denied, and the spread of the Drift material has been referred to flowing water or iceberg transportation. It fortunately happens, however, that a great number of railroad cuts, cellars, wells, and pits of various kinds have been sunk through the Drift to the rock, and these, in a thousand localities, have shown that the rock surfaces which have been protected from weathering by sand and clay still bear the undeniable and distinctly legible autograph of the glacier. Hence, abundant proof can be offered to the doubting that up to the margin of the Drift area, ice has moved in solid sheets from some northern region. By comparing the bearing of the scratches and furrows which it has left in its passage, we also learn that at one time or another streams of ice have flowed from all of the points to which we have traced the transported bowlders. Thus an unbroken chain of evidence proves that the Drift material, now scattered over so much of the surface of Indiana, has come from all this wide northerly region, and that the transporting agent has been for the most part glaciers, and not icebergs, although in the eventful history of the Ice Period icebergs took an important though local and subordinate part.

CAUSES OF THE COLD OF THE ICE PERIOD.

The evidences of the former extension of glaciers into low latitudes have been found not only across North America, but in different parts of Europe and Asia, and similar phenomena to those which constitute our record of an Ice Age, have been detected in various parts of the Southern Hemisphere—Patagonia, Chili, New Zealand and Australia. All these have excited much interest, and many theories have been advanced to account for the former spread of Arctic conditions over the enormous area where they temporarily prevailed. The first and simplest explanation was that given by Lyell, who, with characteristic conservatism, explained the former extension of snow fields and glaciers by supposing that a peculiar topographical condition prevailed in the Northern Hemisphere during the Glacial Epoch. According to his view, the land of the Arctic region was high and continuous at that time, and the ocean currents which now penetrate and warm the Arctic seas, were then excluded by land barriers. In that case, the heat of the tropics would be confined to

the tropics, where it would result in evaporating vast quantities of water, which would be precipitated on the great condensers of the Arctic highlands. But geology shows us that the Arctic highlands were high and broad *in the Tertiary*, and that barriers did then shut the tropical currents out of the Arctic ocean; yet the temperature was in all that region much higher than now. On the contrary, in the Ice Period the northern land was apparently low, as the Champlain clays, which are composed of the fine material ground up by glaciers, were deposited by sea water over a great area in the north which is now land. Beginning at New York with the sea level, they reach an altitude of 200 feet at Albany, 350 in the Champlain valley, 500 in the St. Lawrence valley, 800 in Labrador, 1,000 in Davis' Straits, and 1,500 to 1,800 on the coast of Greenland; and these clays contain Arctic shells and were plainly laid down by the sea during the Glacial Epoch.

Whatever theory is offered to account for the Ice Period must equally apply to the Southern Hemisphere. But it is evident that no barrier of land in recent Geological times connected Cape of Good Hope with Cape Horn and the East Indian Archipelego. Therefore the Lyellian hypothesis, however simple, can not be accepted.

Col. Drayson, the author of *The Last Glacial Epoch*, advocates the view that the angle of inclination of the earth's axis with the ecliptic—which is now constantly changing within narrow limits—was in former times far more variable, and that the North Pole has occupied many different places, giving to each in succession an Arctic climate. Astronomers are generally agreed, however, in rejecting this theory, regarding it as a mere conjecture, sustained by no facts and opposed to all that is known of the mechanism of the solar system.

Without discussing further all the suggestions that have been made in regard to terrestrial causes of the climate of the Ice Period, it may be said that none has yet been offered which has any considerable claim to confidence, and we are almost driven to look to some extraneous and astronomical cause for an explanation of the phenomena. Three theories have been offered which suppose the earth to have been affected by external influences which have at times greatly modified its climate. Of these one supposes the earth to have passed through cold places in the stellar universe, and another that the heat of the sun, which now determines the surface temperature of the globe, has been variable, at times greater and at others less than at present. But no warrant is given for either theory by any observed facts, and the burden of proof lies entirely with their proposers.

Finally, a theory was brought forward by Prof. Croll, of Glasgow, which at once secured a large amount of favor, and at present is very generally accepted as the most plausible of any yet suggested. This theory is that the variations in the eccentricity of the earth's orbit, which have

been carefully calculated for millions of years, forward and back, and shown to have been at times far greater than now, have, in combination with the precession of the equinoxes, caused secular changes in the climate of the Northern and Southern Hemispheres alternately, as great as any which geology reports. In his interesting work, *Climate and Time*, Prof. Croll elaborates his theory at great length, and proves, first, the reality of great variation, and second, its adequacy to account for a share, at least, of the climatic changes recorded.

These propositions can not be denied, but there is some difference of opinion as to the manner and measure of the changes of climate which would result from a great variation in the eccentricity of the earth's orbit. Probably there will never be perfect unity of sentiment in reference to this point, but Prof. Croll deserves the gratitude of the scientific world for suggesting what must have been the cause of marked, and probably great, climatic revolutions.

THE ICE PERIOD A COLD PERIOD.

As ice is a condition of water produced by cold, and glaciers and snow fields are confined to cold portions of the earth's surface, the natural inference from the evidence of the former great extension of glaciers is that they were simply the product of a depression of temperature; but as no accumulation of ice and snow could take place without the precipitation of moisture and the previous evaporation of that moisture in some other locality, it is true that the formation of snow fields and glaciers will be to a certain extent measured by evaporation and precipitation. Hence, several writers upon the Ice Age have taken the view that its characteristics were due rather to an increased evaporation and precipitation than to an increase of cold.

For example, one very distinguished scientist has suggested that in the Ice Period great volcanic eruptions in the tropics threw into the air vast quantities of moisture, which was precipitated as snow and formed ice in all elevated regions, north and south, and thus produced the great snow fields and glaciers, of the existence of which we have such abundant evidence. But there are difficulties in the way of this theory which are quite insurmountable:

1. We have no indications in the tropics of any extraordinary volcanic outbursts, and we may be quite sure that any of such magnitude as to materially affect the precipitation of moisture in the Northern and Southern Hemispheres would have left an unmistakable record. It should be remembered that the evidences of ancient glaciation extend quite around the earth in both Hemispheres, and, even if it were true that volcanic eruptions, like that of Krakatoa, would load the atmosphere with an abnormal quantity of moisture, it would be necessary to have a ring of

such volcanoes quite around the central zone of the earth to produce the general precipitation which this theory requires; and also that the volcanic action should be continued through many thousand years in order that the glaciers might produce the immense erosion, transportation and deposition they effected.

2. It may well be doubted whether the conversion of water into steam in the tropics, on however grand a scale, would result in any great increase of the precipitation in the Arctic regions, since most of the evaporated moisture would rise directly to an altitude where the temperature is so low that it would be condensed and sent back again to the earth in deluges of rain, and the small surplus, if any there were, would, according to the system of atmospheric circulation which now prevails, descend to the surface before reaching the Tropics of Capricorn and Cancer.

A vast amount of moisture is evaporated under the equator at the present time, and yet this is so generally precipitated within the tropics that, as Prof. Loomis has shown, the zone where the air flowing from the equator toward the poles reaches the surface is a zone of special dryness.

3. No increase of annual precipitation would result in rebuilding the glaciers which occupied low latitudes in the Ice Period. For example, the present rainfall on the mountains of Oregon is quite heavy, and the snow accumulates there to the depth of many feet in winter, but in summer this all melts away, except upon certain elevated summits where perpetual snow is by its mere quantity carried down to a level where there is a vigorous forest growth. It is easy to see that an increase of rainfall, however great, on the Cascade Mountains, would never form glaciers without a depression of temperature; but the rainfall continuing the same as now, if the winter temperature of that region could be maintained through the year, glaciers would certainly be formed and spread over the great area they occupied during the Ice Period.

In the same way an increase of rainfall over the drainage basin of the St. Lawrence, a region once covered with glaciers, would never restore the ancient conditions without a depression of the annual temperature. If, however, the cold of the Canadian winter could be continued throughout the year, not many centuries would elapse before the Canadian highlands and all the bordering plain would be covered with ice sheets. Hence, we are forced to the conclusion that the Ice Age was attended with a depression of temperature simultaneously or alternately in the Northern and Southern Hemispheres, and that this depression of temperature, due to some extraneous and not terrestial cause, produced the distinguishing characteristics of the Age.

TABLE OF ALTITUDES OF CHICAGO & INDIANAPOLIS AIR LINE R. R.

BY DR. H. MOORE.

STATIONS.	Distance from Indianapolis.	Elevation Above Ocean.
Indianapolis Union Depot	....	721
Junction	....	762
Broad Ripple depot	8	755
White River rail	8.2	759
Hamilton and Marion county line	12	836
Carmel depot	16	860
Westfield depot	20	935
Hortonville depot	24	945
Sheridan depot	28	980
Sheridan, west corp. line	28.6	998
Boone and Hamilton county line	29	993
Terhune depot	32	994
Clinton and Boone county line	34.5	970
Kirklin depot	37	956
Sugar Creek bed	38	917
Cyclone depot	41	962
Frankfort depot	47	893
South Fork Wild Cat rail	49.5	855
South Fork Wild Cat bed	....	825
Rossville depot	58	740
Middle Fork Wild Cat rail	59	740
Middle Fork Wild Cat bed	....	720
Carroll and Clinton county line	59.2	740
North Fork Wild Cat rail	62	717
North Fork Wild Cat bed	....	659
Radnor depot	66	725
Deer Creek rail	72	717
Deer Creek bed	....	645
Delphi & Wabash R. R	....	689
Wabash River rail	....	650
Wabash River dam below Pittsburg	74	626
Highest point between Wabash and Tippecanoe Rivers	....	683
Tippecanoe River below dam	84	593
Monticello depot	85	675
Monon depot	95	674
Lee depot	100	685
Marlboro depot	105	674
Pleasant Ridge	107	695
Iroquois River bed	110	660
Rensselaer depot	111	670
Surry depot	116	716
Fair Oaks depot	121	697
Rose Lawn depot	128	667
Thayer depot	130	682
Kankakee River	131	670
Lowell	139	700
Creston	142	750
Cedar Lake water summit	144	730
St. John's depot	150	707
Dyer depot	155	640
Hammond	163	....
Lake Michigan water summit	....	585

THE OHIO RIVER FLOODS.

The flood in the Ohio Valley during February and March, 1884, reached a height unprecedented in the river's history. The overflow, in many places, spread out over miles of territory, and the devastating sweep of the waters carried away many thousands of dollars' worth of property. Towns and villages were inundated, and hundreds of people were driven from their homes. There was, in consequence, much suffering, and the damage to property is incalculable.

It has become a matter of vital importance to the public that the causes of the frequent recurrence in late years of the destructive overflows of the Ohio River should be thoroughly understood. The discussions of the question have been theoretical, with little of the essential basis of facts educed by thorough investigation. There have been various theories advanced in the newspapers, some of which are worthy serious consideration.

That the causes of the floods in the Ohio Valley are due wholly to recent conditions is not absolutely true, because it is evident from alluvial deposits that floods have occurred in the Ohio Valley long before the existence of the country was known to white men; but there is no doubt that recent conditions, topographical and atmospheric, have, in a large measure, contributed to the causes of the great and devastating freshets that have swept over the valley in late years.

Mention has been frequently made of an unauthenticated tradition among the Indians, that the waters in the Ohio River once rose to a height little below the level of some of the highest hills along the course of the stream, but the tradition in itself is worthy of no consideration more than mere mention. There is good scientific evidence, however, in the deposits along some of the small tributary streams, which have undoubtedly been left by backwater from the Ohio River. These deposits indicate evidence of glacial floods, but Dr. George Sutton, who has given some time to a careful investigation of the subject, expresses the opinion that "it is also probable that they present evidence that there have been occasional floods in the Ohio River much higher than any that have occurred since the country has been settled." Consequently, regardless of the existence of supposed recent causes, floods in the Ohio River *are likely to occur again*, for the same reasons that they probably did hundreds of years ago.

The general history of the great floods in the Ohio Valley, during the present century, and the matter of the heights reached by the water, and the seasons of occurrence, is embodied in the following:

AT PITTSBURGH.

Year. Month.	Ft.	In.	Year. Month.	Ft.	In.
1832 February	35	0	1877 January	23	7
1847 February	26	0	1880 February	22	0
1867 March	22	6	1882 January	21	9
1875 August	21	9	1883 February	27	6
1876 September	23	3	1884 February	33	4

AT CINCINNATI.

Year. Month.	Ft.	In.	Year. Month.	Ft.	In.
1832 February	64	3	1877 January	53	9
1847 December	63	7	1880 February	53	2
1867 March	55	8	1882 February	58	7
1875 August	55	4	1883 February	66	4
1876 January	51	9	1884 February	71	¾

AT EVANSVILLE.

Year. Month.	Ft.	In.	Year. Month.	Ft.	In.
1832 February	46	7	1877 January	41	5
1847 January	45	6	1880 February	42	10
1867 March	46	3	1882 February	44	9¼
1875 August	41	10	1883 February	47	9½
1876 January	43	0	1884 February	48	¼

The foregoing shows that three of the greatest overflows in the history of the river, since the settlement of the valley, have occurred in the last three years, at the same season. The cause is attributed to the removal of the forests and the drainage of the farm land, in the valley, by tiling. The forests, it is claimed, were absorbents of the water that now rushes down into the river, and the speed of its flow is aided by the washing of the soil from the strata of solid rock beneath. However, this alone is not a satisfactory explanation of the cause of the freshet. The forests had not been removed when the flood in 1832, one of the greatest in the history of the river, occurred. The changes in the topographical condition of the country in the region of the headwaters of the river have unquestionably quickened the drainage, but there were other and more apparent conditions which contributed to the causes of the freshet. A heavy snow had fallen upon the mountains during the winter, and a remarkably low temperature, in one instance dropping to 22 degrees below zero, caused the formation of ice from the source to the mouth of the river. When the thaw began the accumulated snow and ice of the winter sent an immense volume of water down into the channel of the river, accompanied

by a warm rain, throughout the valley, of two weeks almost steady continuance. It was impossible for the river to give immediate outlet to the accumulated water-fall of the season throughout the whole of the valley. The existence of the primitive forests would not have been a sufficient absorbent to have prevented the flood.

There may at any time be a combination of conditions which would produce a freshet in the Ohio River many times higher than any that has yet occurred. If the winter begins early, freezing the ground to a depth of two feet, which would be equivalent to two inches of water, and with warm rains in February upon the accumulated snow-fall of the season, all of which would be no violation of natural laws, a volume of water would be sent into the channel of the river, which would cause an immense overflow. These conditions are likely to arise in any year.

The means of preventing future overflows is a question that needs more thorough practical study than has yet been given it. Hon. Robert S. Taylor, of Indiana, a member of the Mississippi River Commission, in an address before the Merchant's Exchange, of St. Louis, in January, 1884, expressed views in relation to the improvement of the Mississippi River, which are quite apropos in this connection. "The effect of outlets upon the flood levels and upon the river channel," Mr. Taylor says, "has been the theme of great controversy for a generation past. There is a class of aquatic doctors who regard the Mississippi in every time of flood as sick, whose diagnosis of the case is dropsy, and whose remedy is tapping. Bills have been introduced in Congress, and vigorously pushed, to provide for the making of vast outlets by artificial means. The opponents of such measures have claimed that the effect of such diminution of volume in the river is, to lessen its energy and transporting power, and so cause deposits of sediment, which choke up the channel, increase the flood heights, and thus make the last state of the river worse than its first. These views have been supported by many observed facts, and by what seemed to be unanswerable reasoning. Nevertheless, there has been felt by intelligent students of the question a strong desire for more facts, and for facts based on observations so made as to afford the highest possible guarantees of their accuracy."

The existence of forests has but little influence upon the aerial currents which produce the continental storms. Some of these continental storms are over a thousand miles in extent, and deposit over the country the moisture absorbed by atmosphere from the ocean. "It is these continental storms which produce our great floods," remarks Dr. George Sutton, "and a sufficient amount of rain falling in a short time will produce a flood, whether it falls in winter or summer, or on prairie or forest land. The great aerial ocean surrounding the globe in our latitude is always in motion, and this motion upon an extended scale produces fluctuations and variations in our climate, bringing about the wet and dry seasons, the cold

and dry seasons, the cold and the warm years, the floods, the droughts, the storms and tornadoes. The fluctuations produce, one year, floods in the Missouri, at other times in the Mississippi, and at other periods along the valley of the Ohio River. They occur at all seasons of the year—in the winter, when the ground is frozen and covered with snow, and also in summer, as we remember the flood in 1875, when thousands of acres of corn land along the valley of the Ohio River were overflowed."

A GLOSSARY

OF

TERMS COMMONLY USED IN GEOLOGICAL REPORTS.

ACCRETION. The process by which inorganic bodies grow larger, by the addition of fresh particles from the outside.

ACOTYLEDON. A plant in which the seed-lobes (cotyledons) are not present, or are indistinct, like the fern, lichen, and most of the coal plants.

ACROGENS. Plants which increase in height by additions made to the summit of the stem by the union of the bases of the leaves. The highest tribe of *Cryptogams*, such as *Sigillaria, Lepidodendria, Calamites, Ferns*, etc.

AEROLITE. A stone or other body which has fallen from the air, or, more correctly, has come to the earth from distant space; a meteorite.

AGATE. A semi-pellucid, uncrystallized quartz.

ALGÆ. Marine plants, comprising the seaweeds and many fresh-water plants.

ALLUVIUM. Earth, sand, gravel, loam, vegetable mould, etc., washed down by streams and floods, and deposited upon formations not permanently submerged.

ALUMINA. A characteristic ingredient of common clay.

ALUMINOUS. Pertaining to or containing alum, or alumina. The clay slates are very frequently impregnated with alum, and are then called alum-slates or alum-shales.

AMMONITE. An extinct genus of *Cephalopoda*, like the Nautilus, found in the Secondary or Mesozoic rocks; so called from the resemblance of its shell to the horns of Jupiter-Ammon.

AMORPHOUS. Bodies devoid of regular or determinate form. A name sometimes used to designate the sponges.

AMPHIBIA. Animals capable of living either in water or on land, like the frogs, newts, lizards, turtles, certain serpents, etc.

AMYGDALOID. A rock in which crystallized minerals are scattered in almond-shaped cavities.

ANTICLINAL. The crest or line in which strata dip in opposite directions.

ARGILLACEOUS. Clayey; composed in whole or in part of clay.

ARTICULATA. Animals characterized by the possession of jointed bodies or jointed limbs.

AURIFEROUS. Containing gold.

AZOIC ROCKS. Rocks formed before the existence of organic life, or, at least, of animal life, consequently destitute of fossil remains.

BASIN. An isolated or circumscribed formation, particularly where the strata dip inward, on all sides, toward the centre. Especially applied to the coal formations called "coal basins" or "coal fields."

BATRACHIA. The order of reptiles which includes the frog and related animals.

BELLEROPHON. A genus of *Gasteropoda*, having a univalve shell, found in the Paleozoic rocks.

BITUMINOUS SHALE. Shale impregnated with bitumen; usually of a dark brown or black color.

BIVALVE. Consisting of two plates or valves, hinged together with an elastic ligament.

BOWLDER CLAY. The stiff, unlaminated clay of the Drift period.

BOWLDERS. Rocks, rounded or otherwise, which have been transported from more or less distant localities by natural agencies, especially during the Drift period.

BRACHIOPODA. A class of marine mollusks, characterized by two fleshy arms, continued from the sides of the mouth, and which served to create currents to bring them food.

CALAMITE. Extinct plants, with reed-like stems, sometimes attaining a diameter of fourteen inches and the height of trees, found almost entirely in the Coal Measures.

CALCAREOUS. Consisting of or containing carbonate of lime.

CALCITE Crystallized carbonate of lime. Common limestone, all the white and most of the colored marbles, calc-sinter, calc-spar, calc-tufa, stalactites, and stalagmites are so classified.

CARAPACE. A protective shield. The upper shell of the tortoise, turtle, crab, lobster and other *Crustacea.*

CARBONATE. A salt formed by the union of carbonic acid with a base.

CARBONIFEROUS. Producing or containing carbon or coal.

CARBONIFEROUS AGE. The one immediately following the Devonian Age, or *Age of Fishes*, and characterized by the vegetables which formed the coal beds. This Age is divided into the Subcarboniferous, the Coal Measure and the Permian epochs.

CARBONIFEROUS PERIOD. The second, or middle, division of the Carboniferous Age.

CARINATED. Shaped like the keel of a ship. Applied to flowers consisting of two petals, either separate or united, inclosing the organs of fructification, and which have a longitudinal prominence like a keel.

CARPOLITE. Petrified fruit. Literal meaning, "stone fruit."

CENOZOIC. Belonging to the Tertiary period, and means "recent life."

CENTIMETRE. A French measure of length, equal to .39368 of an inch.

CEPHALOPODA. A class of the *Mollusca*, comprising the cuttle-fishes and their allies, and characterized by a distinct head, surrounded by a circle of long arms or tentacles, which they use for crawling and for seizing objects.

CHERT. An impure, massive, flint-like quartz, or hornstone, of various dull shades of color.

CHONETES. A genus of fossil bivalve shells, of the class *Brachiopoda.*

CINCINNATI GROUP. The upper division of the Lower Silurian system. Same as *Hudson River Group.*

CLEAVAGE. That peculiar structure in rock which admits of its division into scales or layers.

COAL BASIN. Depressions formed in the older rock formations, in which coal-bearing strata have been deposited.

COAL MEASURES. Strata of coal, with the attendant rocks.

CŒLENTERATA. Proposed by Frey and Leuckhart, in place of the old term *Radiata*, for animals having "hollow bowels," which this term literally means.

CONCHIFERA. A species of the *Mollusca* having shells with a dorsal hinge, like the oyster, clam, mussel, and other ordinary bivalves. Literal meaning, "to bear a shell."

CONFORMABLE. Parallel, or nearly so; said of strata which lie in contact.

CONGLOMERATE. A rock, composed of pebbles cemented together by another mineral substance, either calcareous, siliceous or argillaceous.

CONIFERA. The order of the firs, pines and their allies, in which the fruit is generally a "cone" or "fir-apple"; literally, "I carry a cone."

CONTORTED. Strata which have been bent or twisted while in a soft and yielding condition.

Coprolites. Fossilized excrements of animals.

Coral. The solid secretion of zoophytes, produced within the tissues of the polyps, and corresponding to the skeleton in higher animals. It consists almost purely of carbonate of lime.

Coralline Zone. That zone of marine life which extends from about 90 feet to 300 feet in depth.

Corallum. The coral or solid part of a zoophyte, whether composed of stone or horn.

Crag. A partially compacted deposit of the older Tertiary formation, consisting of sand and shells.

Cretaceous. Having the qualities of chalk; the uppermost or last of the Secondary formation.

Crinoidea. An order of lily-shaped marine animals, belonging to the subkingdom *Radiata*. They generally grow attached to the bo tom of the sea by a jointed stem, though some are free.

Crustacea. One of the classes of the *Articulata*, comprising lobsters, shrimps, and crabs, characterized by the possession of a hard shell or crust, covering the body, legs, etc.

Cyathiform. In the form of a cup or drinking-glass, a little widened at the top.

Cyathophyllum. Cup-shaped, rugose corals, very abundant in the rock formations of Indiana.

Debris. Broken and detached fragments of rocks, taken as a mass or collectively.

Degradation A gradual wearing down or wasting, as of rocks, banks, and the like, by the action of water, frost, etc.

Denudation. The laying bare of rocks by the action of running water, or by removing earth, etc.; also, the excavation of rocks by running waters or by the action of waves.

Deposit. Matter precipitated from suspension in water.

Detritus. Small portions of matter worn off from rocks by attrition.

Devonian. Applied to rock strata lying next above the Silurian.

Dicotomy. Dividing regularly by pairs.

Dip. The downward inclination of strata.

Drift. A collection of loose earth, sand, rocks, or bowlders, distributed over a large portion of the earth's surface, especially in latitudes north of 40°, and which have come from the northward, brought thence, mainly, by glacial action.

Encrinite. The lily-shaped radiate; crinoid.

Eocene. The lowest division of the Tertiary rocks, in which but few specimens of existing shells are found.

Eozoic. A term used for the oldest fossil-bearing rocks yet known, such as the Laurentian and Huronian of Canada.

Epoch. The period during which a formation was produced; thus, geologists speak of the Millstone Grit epoch, etc.

Escarpment. The steep face presented by the abrupt termination of strata.

Fault. A sudden interruption of the continuity of strata or veins in the same plane, caused by a crack or fissure.

Fauna. The animals of any given area or epoch.

Favosites. A kind of fossil coral, having a prismatic structure closely resembling that of a honey-comb.

Ferruginous. Containing iron; also, partaking of the quality of iron.

Fire-Clay. Any clay capable of sustaining intense heat without vitrifying. Abundant in the Coal Measures, beneath each coal seam.

Fissile. Capable of being split, cleft, or divided in the direction of the grain.

Flora. The system of vegetable species native in a given locality, region, or period; as the Flora of the Coal Measures, etc.

Fluviatile. Belonging to rivers; formed by rivers, as fluviatile strata.

Fluvio-marine. Formed by the joint action of a river and the sea, as in the deposits at the mouths of rivers.

Foliated. Having leaves or leaf-like projections, as foliated shells; composed of thin laminæ or layers, as mica schist, schistose, and the like.

Foraminifera. A minute genus of the *Protozoa*, characterized by having a calcareous shell perforated by numerous pores, or foramina.

Formation. The series of rocks belonging to an Age, period, or epoch, as the Silurian formation, and the like.

Fossil. That which may be dug up; the petrified form of a plant or ani-

mal in the strata composing the surface of the earth.

FOSSILIFEROUS. Containing fossils or organic remains, as fossiliferous rocks.

FUCOIDS. Fossils resembling sea-weeds.

FUSIFORM. Shaped like a spindle; tapering at each end.

FUSILINA. A spindle-shaped *Foraminifer*.

GASTEROPODA. A univalve mollusk, having a fleshy ventral disk, which serves to take the place of feet; as the snail.

GEMMATION. The formation of a new individual by the protusion of any part of an animal or plant, which may then become free or remain connected with the parent stock; budding. Polyps and some other animals reproduce by buds.

GENUS. An assemblage of species possessing certain characters in common, by which they are distinguished from all others.

GEODE. A rounded nodule of stone, containing a small cavity usually lined with crystals, sometimes with other matter; the cavity in such a nodule.

GEOLOGY. A science which treats of the materials which compose the earth, the methods in which those materials have been arranged, and the causes and modes of origin of those arrangements.

GLACIAL RIVER; GLACIER. A field or immense mass of ice, or snow and ice, formed in the region of perpetual snow, and moving slowly down mountain slopes or through valleys, usually bearing along bowlders and fragments of rock.

GNEISS. A crystalline rock, consisting of quartz, feldspar and mica, but, unlike granite, having these materials arranged in planes, so that it rather easily breaks into coarse slabs or flags.

GRANITE. A crystalline rock, of the same materials with gneiss, but differing therefrom in these materials being grainy and not stratified.

GYPSUM. Sulphate of lime. Plaster of Paris is made from this mineral by calcination.

HABITAT. The natural abode or locality of an animal or plant.

HÆMATITE. Sesqui-oxide of iron. So called because of the red color of the powder.

HEMIPRONITES. A fossil bivalve shell, sometimes known as the genus *Streptorhynchus*.

HETEROCERCAL. A fish having the vertebral column continued into the upper lobe of the tail, which lobe, on this account, is larger than the lower one. Literal meaning, "A diverse tail." This form prevailed in Paleozoic times.

HOMOCERCAL. A fish in which the vertebral column terminates at the commencement of the tail, the lobes of which are symmetrically equal. Literal meaning, "Common tail."

HUDSON RIVER GROUP. An upper division of the Lower Silurian formation. Same as Cincinnati Group.

HUMUS. A dark brown substance formed in the soil by the action of air on solid animal or vegetable matter. It is a valuable constituent of soils.

ICHTHYOLOGY. The science of the systematic arrangement or classification of fishes.

IGNEOUS ROCKS. Resulting from the action of fire; such as lavas, basalt, trap, and the like.

IMBRICATED. Lying over each other in regular order, like the scales of a fish and those on the leaf-buds of plants.

INFUSORIA. Microscopic animals found in water and other fluids, multiplying by gemmation.

INORGANIC. Devoid of an organized vital structure. Rocks, minerals and all chemical compounds are inorganic substances.

IN SITU. In its original situation. Said of rocks which remain where they were formed.

INVERTEBRATA. Animals without a spinal column.

LACERTIAN. The lizard species.

LACUSTRAL. Pertaining to lakes or swamps.

LAGOON. A marsh, shallow pond, or lake, especially one into which the sea flows.

LAMINATED. Consisting of plates, scales or layers, one over another.

LAND-SLIP. The sliding down of a considerable tract of land.

LENTICULAR. Having the form of a double-convex lens.

LEPIDODENDRON. A genus of fossil cone-bearing trees, belonging to the Carboniferous Age, and so-called from having their stems marked with scars or scales, produced by the falling off of the leaves.

LIGNITE. Mineral coal showing the texture of wood, and found in the Tertiary formation.

LINE OF BEARING. The direction of the strike, or outcrop.

LINE OF DIP. The line of greatest inclination of a stratum to the horizon.

LITHOLOGY. The science which treats of the characteristics and classification of rocks.

LOAM. A soil composed of siliceous sand, clay, and carbonate of iron, with more or less oxide of iron, magnesia, and various salts, and also decayed animal and vegetable matter.

LOESS. A division of the Quaternary System, Lacustral Age. Common along the Mississippi and many of its tributaries.

LOWER CARBONIFEROUS PERIOD. The first, or earliest, division of the Carboniferous Age.

MAMMALIA. Vertebrate animals that suckle their young.

MAMMOTH. An extinct elephant, fossil remains of which have been found on both American continents.

MARL. A mixture of carbonate of lime, clay, and sand in varying proportions. A valuable fertilizer.

MASTODON. An extinct gigantic mammal, resembling the elephant, so called from the conical (nipple-shaped) protuberances on its molar teeth (grinders).

MATRIX. The earthy or stony substance in which metallic ores or crystalline minerals are found.

MESOZOIC. The Secondary period. Literal meaning, "Middle life."

METAMORPHIC. Rocks or minerals which have undergone changes in form or shape since their original deposition; usually applied to changes made by heat.

METEORITE. Same as Aerolite; which see.

METRE. A French measure of length, equal to 39.368 inches. (See, also Centimetre and Millimetre.)

MICA SLATE. A schistose rock, consisting of mica and quartz, with, usually, some feldspar. The lowest stratified rock except gneiss. It bears no fossils.

MILLIMETRE. A French measure of length, equal to .039368 of an inch.

MILLSTONE GRIT. A hard, gritty, sandstone, a kind of conglomerate, found under the Coal Measures, sometimes containing quartz pebbles.

MIOCENE. The middle division of the Tertiary rocks, in which the minority of the organic fossils are of recent species.

MOLLUSCA. Invertebrate animals, having a soft fleshy body (whence the name), which is inarticulate, and does not radiate internally. Includes the shell-fish proper.

NAUTILUS. A fossilized and living genus of the Molluscan Cephalopods.

NIAGARA GROUP. A division of the Upper Silurian system.

NODULE. A rounded mass of irregular shape.

NUCLEUS. A kernel; a central mass or point, about which other matter is gathered.

OOLITE. An epoch in the Jurassic Age. A variety of limestone, consisting of round grains like the roe of a fish. Name is derived from two Greek words, which mean "Egg-stone."

OOLITIC. Resembling Oolite.

ORGANIC REMAINS. Fossilized remains of animals or plants.

ORTHIS. A genus of *Brachiopoda*, named in allusion to the straight hinge-line.

ORTHOCERAS. A family of the *Nautilidæ*, in which the shell is straight, or nearly so.

OUTCROP. That part of an inclined stratum which shows at the surface of the ground.

PALEONTOLOGY. The science of the ancient life of the earth, or of the fossils which are the remains of such life.

PALEOZOIC. Applied to the older division of geological time and the fossil-bearing rocks of the Silurian, Devonian, and Carboniferous Ages.

PEAT. Accumulation of vegetable matter, on and near the surface of the earth, in moist places. It is intermediate between pure vegetable matter and lignite, 80 parts in 100 being combustible, and is, therefore, often dried, and then used for fuel.

PERMIAN. The epoch following the Coal Measure epoch, and regarded as closing the Carboniferous Age and the Paleozoic era.

PLEISTOCENE. Quaternary. Pertaining to the epoch or to the deposits following the Tertiary, and immediately preceding man. Compounded from two Greek words, meaning "most new."

PLIOCENE. The upper division of the Tertiary period. Meaning, "more new."

PLUTONIC ROCKS. Those deriving form from igneous action.

POLYPI. Radiates, having many feet (whence the name) or feelers.

POLYZOA. The lowest order of *Mollusca*, in which many animals are united in one structure. A compound group among the *Bryozoa*.

PRIMITIVE (or PRIMARY) ROCKS. Rocks supposed to be first formed, being irregularly crystallized, aggregated without a cement, and containing no organic remains, such as granite, gneiss, and the like.

PRIMO-CARBONIFEROUS. Upper Coal Measures (?). See "Coal Measures," *ante*.

PRODUCTUS. An extinct genus of *Brachiopoda*, in which the shell is "eared," or has its lateral angles drawn out.

PROTOZOA. The lowest division of the animal kingdom.

PTERODACTYL. A winged saurian; a fossil reptile which had the little finger of the hand greatly elongated, for the purpose of bearing a membraneous wing. Meaning, "wing-finger."

PTEROPODA. A class of *Mollusca*, which swim by means of fins attached near the head. Meaning, "wing-foot."

PUDDING STONE. A coarse conglomerate, composed of siliceous or other pebbles, united by a cement.

PYRITES. A combination of sulphur with iron, copper, cobalt or nickel.

QUAQUA-VERSAL. Dipping toward all points of the compass from a central point, as beds of lava around a crater.

QUARTZ. Pure silex, occurring in pellucid, glassy crystals, having the form of a six-sided prism, terminated at each end by a pyramid. The crystals are usually clear, but sometimes are variously colored, more or less transparent, and even opaque.

QUARTZITE. Granular quartz; sandstone that has been changed by metamorphic action to a hard quartz rock.

QUATERNARY. Later than the Tertiary; equivalent to the English Pleistocene.

RADIATA. One of the great sub-kingdoms of animals, in which all the parts are arranged uniformly around the longitudinal axis of the body, such as star-fishes, corals, crinoids, etc.

RASH COAL. An impure coal.

RECENT. Of a date subsequent to the creation of man.

RENIFORM. Kidney-shaped; applied to certain minerals.

RECEPTACULITES. An extinct genus of *Protozoa*. Meaning, "A stone receptacle."

REPTILIA. The class of *Vertebrata* comprising snakes, lizards, tortoises, turtles, etc. From Latin verb *repto*, "I crawl."

RETICULATED. Having sets of parallel fibres or lines crossed by others, likewise parallel, so as to form meshes resembling those of a net.

RHYNCHONELLA. A small bivalved Brachiopod, having a *rynchos* (nose or beak).

RHYNCHONELLA OSAGENSIS. Same as *R. Pecosi.*

RHYNCHONELLA PECOSI. Same as *R. Osagensis.*

ROCK. Any natural deposit of stony material.

RUGOSE. Wrinkled; full of wrinkles.

SAURIAN. Any lizard-like reptile.

SEAM. A layer of substance, more or less wide, parallel with the stratification of surrounding material.

SEDIMENTARY ROCKS. Those formed from materials precipitated from suspension in water.

SEISMOLOGY. The science of earthquakes and their characteristics.

SERRATED. Notched on the edge like a saw.

SHALE. A fine-grained rock, having a slatey structure; an indurated clay, deposited in thin layers.

SHELL MARL. A deposit of shells, which have been disintegrated into a gray or white pulverulent mass.

SIGILLARIA. Fossil trees, the bark of which is covered with impressions as if by a seal. Found in the Coal Measures.

SILEX. Silicic acid, generally impure, as it is found in nature, constituting flint, quartz, and most sands and sandstones. Literal meaning, "Flint."

SILICEOUS. Composed of silex.

SILT. Mud or fine earth deposited from running or standing water.

SILURIAN. The earliest of the Paleozoic formations; so called from the country of the Silures, who anciently inhabited a part of England and Wales, because the strata was most plainly developed in that country.

SIPHUNCLE. A tube of a membraneous or calcareous nature, transversing the septa of a chambered shell.

SLATE. An argillaceous stone which easily spilts into plates.

SOAPSTONE. A soft magnesian mineral, usually gray, white, or yellow; so called from its soapy or greasy feel; steatite; pot-stone.

SPIRIFER; SPIRIFERINA. Extinct species of *Brachiopoda*, with large spiral supports for their "arms."

STALACTITES. Icicle-like encrustations and deposits of lime, which hang from the roof and sides of caverns hollowed out of limestone.

STALAGMITES. Encrustations of lime formed on floors of caverns hollowed out of limestone.

STIGMÁRIA. Stem-like, fossilized vegetation, often traversing the under clay of the coal, and supposed to be the roots of *Sigillaria;* which see *supra.*

STRATIFIED. Formed in regular beds or layers.

STRATUM (pl. STRATA). A bed of earth or rock of any kind, formed by natural causes, and usually consisting of a series of layers.

STREPTORHYNCHUS. Often called *Hemipronites.*

STRIKE. The horizontal direction of the out-cropping edges of tilted rocks, which is always at right-angles to the dip.

SUBCARBONIFEROUS PERIOD. Same as Lower Carboniferous Period.

SUTURE. The line of junction of two parts which are immovably connected together, like the line where the whorls of a univalve shell join, or the lines made on the exterior of a chambered shell by the margins of the septa.

SYNCHRONISM. Concurrence in time of two or more events; contemporary; simultaneousness.

SYNCLINAL. Formed by strata dipping toward a common line or plane, as a synclinal trough or valley. The opposite of *Anticlinal;* which see, *supra.*

TALUS. A sloping heap of rock fragments lying at the foot of a precipice.

TERRACE. A shelf or bank of earth having an uniformly level surface.

TERTIARY. Third in order. Applied to the first period of the Age of Mammals, or Cenozoic time; also, to the rock formations of that period.

TEST. A shell, as of a mollusk.

TESTACEA. Mollusks are sometimes so called.

THERMAL. Hot, warm. Applied to springs which discharge water heated by natural agencies.

THIN OUT. Applied to beds or strata which grow gradually and continually thinner in one direction, until they entirely disappear.

TRANSITION ROCKS. The lowest uncrystalline stratified rocks, supposed to contain no fossils, and so called because thought to have been formed when the earth was passing from an uninhabitable to a habitable state.

TRAP. A heavy, igneous rock, of a greenish-black or grayish color, generally composed of feldspar, augite, and hornblende; so called because the rocks of this class often occur in large tabular masses, rising above one another like *treppe*, steps

TRILOBITE. Three lobed. An extinct family of *Crustacea*, which derives its name from its body being so divided.

TUFA. A soft or porous stone, formed by depositions from water, usually lime-bearing, in which case the result is called calcareous tufa. Also a volcanic sand-rock, rather friable, formed of agglutinated volcanic earth or scoria.

UMBO. The beak (the point immediately above the hinge) of a bivalve shell is so called from its fancied resemblance to the "boss of a shield."

UNCONFORMABLE. Not lying in a parallel position; applied to rock strata.

UPPER COAL MEASURES. Upper strata of the coal system.

VEIN. A seam or parting of any substance, more or less wide, intersecting a rock or stratum, and not corresponding with the stratification.

VENTRAL. Belonging to the belly, or the surface opposite the back, or dorsal side. Sometimes used to designate the interior surface of the body.

VERTEBRATA. The division of the animal kingdom which is furnished with a spinal column.

WHORL. The spiral turn of a univalve shell.

ZAPHRENTIS. A genus of rugose (wrinkled) fossil corals.

INDEX.

PART FIRST.

GEOLOGICAL REPORT, 1884.

ERRATUM.

Page 32. Judge Chas. H. Test, in a letter to Dr. Adams, of Greenville, Indiana, dated October 15, 1879, says: "I was employed, with James Noble, to prosecute the murderers of the Indians, and not to defend, as I have seen asserted in some accounts." The trial was in Madison county, in the year 1824. C.

INDIANA.

THE

FOURTEENTH REPORT

OF THE

STATE GEOLOGIST.

(Part Second.)

Post-Pliocene Vertebrates of Indiana.

By E. D. COPE and JACOB L. WORTMAN.

1884.

JOHN COLLETT, State Geologist.

POST-PLIOCENE VERTEBRATES OF INDIANA.

The State Geologist has great pleasure in presenting the following carefully prepared paper on the ancient animals of the State. Each genus and many of the species are introduced by popular descriptions and deductions, followed by scientific explanations so necessary for the expert and the student, thus gathering the whole subject in short, concise information for the special and general reader.

Prof. E. D. Cope, so well known as an indefatigable student, and in the foremost ranks of comparative anatomists, has been assisted by Jac. L. Wortman.

This paper and accompanying figures answer questions which have been asked thousands of times, not only by the boys and girls, but as well by the men and women of the State.

JOHN COLLETT,
State Geologist.

LETTER OF TRANSMITTAL.

To John Collett, State Geologist of Indiana:

SIR—We have the honor to transmit herewith our report upon the collection of vertebrate remains recently placed in our hands by yourself for determination and study. It consists for the most part of remains derived from deposits of Post-Pliocene age in various parts of the State, and includes a number of species which are extinct.

It is highly probable that the present list displays but a small proportion of the species that inhabited the State during the Post-Pliocene or Quaternary period, and it may be expected that the future will reveal many additions to the list. It has been our endeavor to present in the following list a popular account of each species, detailing at the same time, in cases of extinct ones, whatever legitimate inferences can be drawn in regard to their size, probable habits, range and relations to living allies.

Very respectfully,

E. D. COPE,
J. L. WORTMAN.

PHILADELPHIA, May, 1883.

AN ACCOUNT

OF THE

MAMMALIAN FAUNA OF THE POST-PLIOCENE DEPOSITS

IN THE

STATE OF INDIANA.

BY PROFESSOR EDWARD D. COPE AND JACOB L. WORTMAN.

Since the species contained in the following list refer almost exclusively to the Post-Pliocene or Quaternary period it seems proper in this connection, and in keeping with the objects to be attained, to give a brief summary of the chief geological facts that have been ascertained in reference to it; together with a short consideration of the faunal relations it holds to the period immediately preceding it (Pliocene), and the one which succeeds it in time (Recent).

According to geological authority it is characterized as "a period of great and widely extended oscillations of the earth's crust in high latitude regions, attended with great change of climate," and divisible into three epochs as follows: Glacial, Champlain, and Terrace epochs, respectively. During the Glacial epoch the land surface in the northern hemisphere is supposed, for sufficient reasons, to have undergone great elevation; and there appears to be abundant evidence to show that the climate changed from a semi-tropical one, which obtained in the north temperate region during the Pliocene period, to that of the most intensely frigid character in the early Quaternary. This is especially indicated by the marks left by enormous glaciers in the form of drifts, moraines, rock markings, etc., which are found as far south as northern Pennsylvania in the eastern United States. They likewise touched southern Ohio and Indiana,*

*To Ohio river.

and stretched thence westward to the Rocky mountains and the Pacific coast. This period of elevation was followed by one of general depression, in which much of the land surface was covered by great inland fresh water seas. Thus it has been shown that Lake Champlain was connected with the Atlantic ocean by way of the St. Lawrence river; and it seems highly probable that the great lakes of the northern United States were connected with the Gulf of Mexico, submerging the whole Mississippi valley. This epoch constitutes the Champlain. From this submerged condition the land was gradually elevated to its present level, when the continent assumed the physical characters which it now bears. From the time when re-elevation began until the continent was restored to its present level is usually reckoned as the Terrace epoch. From this point geologists begin the Recent period.

Viewed from the standpoint of paleontological evidence the Post-Pliocene period is distinguished, in North America at least, by the presence of a number of animals which do not now exist within its borders, and a large proportion of which are entirely extinct. It is questionable, indeed, whether evidence of this character furnishes any support to the three subdivisions of the geologists already mentioned. Prominent among the distinguishing features of the Post-Pliocene fauna may be mentioned first of the *Carnivora*, or flesh-eating order, the great American lion, *Felis atrox*, described by Dr. Joseph Leidy, from near Natchez, Mississippi. This species, which is known from the lower jaw only, now preserved in the museum of the Academy of Natural Sciences, Philadelphia, was as large as the great cave lion of Europe, *F. spelæa*, and may, according to Dawkins, upon further investigation, prove identical with it. Its size was fully equal to that of the largest existing lion. Besides this one there were two other feline animals of formidable proportions, *Smilodon fatalis*, Leidy, from Texas, and *Smilodon gracilis*, Cope, from the Port Kennedy bone cave, Pennsylvania. They are sabre-toothed tigers, and are characterized by very long and powerful canine teeth. The first of these was equal in size to the Bengal tiger, with canines projecting from the jaw six or seven inches. The second was smaller. There was also a large species of wolf, *Canis indianensis* (?), Leidy, from the banks of the Ohio river, near Evansville, Indiana, as large as the grey wolf. Of the weasel kind there existed a large species, *Putorius macrodon*, described by Cope, from Maryland, about the size of the otter. Of the bear family we have a large extinct species, *Arctotherium simum*, described by Cope, from the bone caves of California, which equaled, if not exceeded, in size the largest grizzly of that region.

Of the even-toed ungulate division (*Artiodactyla*), it is proper to mention a species of extinct buffalo, *Bison latifrons*, Leidy, a gigantic animal at least one-third larger than the largest buffalo of the plains; two extinct species, *Ovibos cavifrons* and *O. bombifrons*, related to the musk-ox of t e

north, from the Big Bone Lick, Kentucky, and elsewhere; a species of elk, *Cariacus americanus*, Harlan, from the same locality, as large as the great Irish elk, *Megaceros hibernicus*, Owen; two species, *Platygonus compressus* and *P. vetus*, Leidy, from various localities, related to the peccaries; and an extinct species of peccary, *Dicotyles nasutus*, Leidy, from Indiana.

Of the odd-toed group (*Perissodactyla*), there were two species of tapir, *Tapirus americanus* and *T. haysii*, Leidy, from the Southern and Middle States; at least two species of horse, *Equus fraternus* and *E. major*, Leidy and Dekay, from various parts of the Eastern United States.

The Proboscidian order was represented by the mighty mastodon, of which there appears to be but a single Post-Pliocene species, *Mastodon americanus*, together with one well marked species of elephant, the hairy *Elephas primigenius*, somewhat smaller in size.

The *Rodentia*, or gnawing order, show several striking peculiarties in this period, in *Castoroides ohioensis*, Foster, a gigantic beaver-like animal, as large as the American black bear; and a peculiar extinct form, *Amblyrhiza inundata*, Cope, from the southern States and West Indies, which appears to belong to the porcupine division of the order (*Hystricomorpha*). This peculiar and interesting animal, as has been ascertained by Cope, was as large as a small sized deer. Besides these, there was a species of Capybara, *Hydrochœrus œsopi*, Leidy, from the Southern States.

The sloth tribe appears to have been abundantly represented by at least three genera and a number of species. The former are *Mylodon*, *Megatherium* and *Megalonyx*.

The foregoing comparison displays the most salient characteristics of the Post-Pliocene fauna as contrasted with that of the Recent, but it must be remembered that the remains of a large number of existing forms are found associated with the extinct ones, and some even date their existence from the Pliocene period. When we attempt to compare its fauna with that of the Pliocene on the other hand, we are at the very threshold beset with many serious difficulties. From the confused condition and imperfect knowledge we at present possess of the exact limits of the Pliocene in this country, it is difficult, if not impossible, to say whether the older cave deposits, containing so large a percentage of South American Pampean forms, refer to the Pliocene or Post-Pliocene period. It has been urged by Prof. Cope that the so-called Pliocene deposits of Kansas and Nebraska, commonly known as the Loup Fork beds, contain too large a percentage of Miocene types to be referred to the Pliocene period. If this be true, and the Pampean deposits of South America be regarded as Pliocene, there seems to be no other alternative than to regard the older cave deposits in this country, or such deposits characterized by the presence of *Mylodon*, *Megalonyx* and *Megatherium*, as truly Pliocene in age. However this may be, without attempting to solve this mooted

question at present, and for the sake of convenience, we will provisionally regard the former already mentioned as belonging to the Post-Pliocene.

The deposits in which mammalian remains of this period are most frequently found are those of (1) caves; (2) marshes and peat-bogs; (3) drifts; (4) sands and clays of fresh water lakes; (5) beaches and terraces; (6) ice cliffs and frozen soils. We are not informed of the character of the deposits from which the following remains have been obtained, which would be a matter of some interest.

CARNIVORA.

Professor Owen remarks: "As the order *Carnivora* includes the most noxious and dangerous quadrupeds, and those which oppose themselves most to the profitable domestication of the useful herbivorous species, it has suffered the greatest diminution through the hostility of man, wherever arts and civilization, and especially those of agriculture, have made progress." This accounts for the extensive disappearance of the great majority of our existing carnivorous mammals from the regions east of the Mississippi River. In the densely wooded and mountainous districts, however, there still linger a few of the more formidable species, which have become species of the past, as far as the cultivated regions are concerned. The five families of terrestrial *Carnivora*, viz.: *Felidæ*, *Canidæ*, *Mustelidæ*, *Ursidæ* and *Procyonidæ*, now living within the limits of the United States, are at present principally confined to forest regions, which formerly extended over the entire East. Of this order we are at present concerned with but a single family.

CANIDÆ. (Dog Family.)

This group embraces the genera *Canis* and *Vulpes*, including at least seven species now living within the limits of the North American continent. During the Miocene and Pliocene periods we meet with a number of extinct genera to which Prof. Cope refers twenty-five species.* None of these appear to have attained a size greater than that of the grey wolf of our own time, but many present curious modifications, which constitute approaches to other families, much nearer than we now see in living species of this group.

CANIS LATRANS, Say. (Coyote).

The specimens upon which this determination is made, consist of the proximal portions of both humeri, the distal extremity of the left humerus, the shaft of a radius, and the distal portions of a left femur and left tibia.

* "On the extinct Dogs of North America," American Naturalist, March, 1883.

They were found in association with the remains of the mammoth in Boone county, and are contained in the collection submitted to our inspection. These remains may, as far as size or any differential characters they possess are concerned, be referred to a domestic dog (*Canis familaris*) as well as to the above species; there is so little difference between certain breeds of dogs and the coyote that it is often a matter of great difficulty, if not an impossibility, to distinguish between them, even when we are in possession of the entire animal.

Certain it is that the limb bones furnish no distinguishing characters. There is, however, a character which seems to have been overlooked, to be found in the teeth.* If the adult unworn teeth of the two species be carefully compared, it will be seen that the cusps upon the posterior molars of the coyote are sharper and more pronounced than those of the dog; the blades of the sectorial, or flesh teeth, are thinner, more elevated, and the teeth themselves have less transverse extent than the corresponding ones in the dog.

With reference to the distinctness of these species, and their capacity for interbreeding, we can not do better than quote the interesting conclusions reached by Dr. Elliott Coues, published in the American Naturalist, 1873, p. 385, in which he says: "Next we continually find dogs of both sexes on the frontier deserting their haunts at particular (sexual) periods, and if the occurrence of a feral wolf-dog (female coyote and a male dog) has not been recorded, there are numerous cases of the production of the same from male coyotes and female dogs in domestication. I have, finally, information which I consider perfectly satisfactory in still stronger evidence of the readiness with which the two animals interbreed. * * *

"Indians not unfrequently bring it about themselves. On suitable occasions they picket out their female dogs over night to procure the cross, with constant success.

"These crosses are not known to be otherwise than fertile, and the result is, in every Indian community there are mongrel dogs shading into coyotes in every degree—all having the clear wolf strain, and some being scarcely distinguishable from the prairie wolf."†

If failure to interbreed be any test of specific distinctness, then it would appear that the coyote is but a wild dog at best, and we can readily recognize the fallacy of Dr. J. E. Gray's arrangement in establishing a sepa-

* Cope, Proceedings Academy, Philadelphia, 1879, p. 184.

† During extended travel in western United States my experience has been the same as that recorded by Dr. Coues. It is by no means uncommon to find mongrel dogs among many of the western Indian tribes, notably among Umatillas, Bannocks, Shoshones, Arrapahoes, Crows and Sioux, which, to one familiar with the color, physiognomy and habits of the coyote, have every appearance of blood relationship, if not, in many cases, this animal itself in a state of semi-domestication. The free interbreeding of these animals, with a perfectly fertile product, has been so often repeated to me by thoroughly reliable authorities, and whose opportunities for observation were ample, that I feel perfectly willing to accept Dr. Coues' statement. J. L. W.

rate genus (*Chrysocyon*) for its reception. It would not prove a matter of surprise if future writers on the subject would discard the species altogether, and reduce it to the rank of a variety, where it seems to belong. What is here said of the interbreeding qualities of the prairie wolf with the domestic dog is probably also true of the gray wolf, but the evidence is not so conclusive. If the remains in question refer to the coyote, it would indicate a more extensive range formerly than the one it now occupies.

Canis lupus, Linn. (Grey Wolf.)

Although not indicated in the collection, yet there is now preserved in the museum of the Academy of Natural Sciences, Philadelphia, an almost complete maxillary bone of the left side of the upper jaw of a large wolf, containing all the molar and premolar teeth, except one. This specimen, together with the remains of *Megalonyx*, *Bison*, horse, tapir, and deer, were obtained by Mr. Francis A. Lester, from the banks of the Ohio river, near the mouth of Pigeon creek, a short distance below Evansville, Ind., and were described by Dr. Leidy, in Proceedings Academy Natural Sciences, Philadelphia, for 1854, under the name of *Canis primævus*. This name being pre-occupied, it was afterwards called *Canis dirus* by the same author, who finally in Journal Academy, Philadelphia, 1867, settled upon the name *Canis indianensis* to designate the remains.

This species was proposed upon size alone, and Dr. Leidy remarks: "Certain naturalists may regard the fossil as an indication of a variety only of *Canis lupus*, and of the correctness of this view I will not attempt to decide." Since the Doctor seems to have been somewhat in doubt as regards the distinctness of the fossil from the ordinary grey wolf, it is proper, with the increased facilities we now have for extensive comparisons, that we attempt to demonstrate the true position and rank of the fossil in question. For this purpose we have selected a series of five crania of American grey wolves from the museum of the Academy of Sciences, Philadelphia, representing the extremes of modification, and noted carefully the differences, or the amount of individual variation, which we are compelled to admit within the limits of the species. In the following table, No. 1 is a cranium from New Mexico; No. 2, from Ohio; No. 3, from Missouri; No. 4, from Kansas; and No. 5, is the so-called *Canis gigas* of Townsend, from Oregon, which has never been admitted by authors to be more than a variety of *Canis lupus*. The following are the more important measurements, as compared with the fossil jaw:

FOSSIL MEASUREMENTS.

Measurements in Twentieths of an Inch.	No. 1, from New Mexico.	No. 2, from Ohio.	No. 3, from Missouri.	No. 4, from Kansas.	No. 5, from Oregon.	Fossil.
Greatest length of cranium . . .	175	180	190	208	219	. . . . .
Width between zygomata	93	91	107	106	120	. . . . .
From back of last molar to base of canine	63	70	66	72	79	92
From back of last molar to front of sectorial	34	40	35	36	39	44
From back of third premolar to base of canine	30	32	29	36	39	46
Dimensions of last molar tooth (breadth x length)	10 x 7½	13 x 8½	10 x 6	9½ x 7	11 x 8½	12 x 8
Dimensions of penultimate molar	15 x 12	20 x 15	17 x 13	17 x 13	18 x 13	19 x 15
Length of sectorial	16	21	19	20	22	26?

It will be seen by reference to the above figures, that the entire length of the cranium varies from 175 to 219, a difference of 44, while the width between the zygomata ranges from 91, in No. 2, to 120, in No. 5, a difference of 29-twentieths inches. The greatest difference in the total length of the molar and premolar teeth of the recent specimens is 16, while the difference between the corresponding parts of the largest of the recent crania, and the fossil is only 13. The greatest difference observable from the back of the last molar to the front of the sectorial among the recent specimens is 6, while the difference between the largest of the recent in this measurement (No. 2) and the fossil, is but 4. From the back of the third premolar to base of the canine tooth, it will be seen varies 9, among the recent crania, while between the greatest length of the recent and that of the fossil is only 7. In the dimensions of the last two molars, the specimens from Ohio (No. 2) exceeds those of the fossil in size, although much smaller in every other measurement. The length of the sectorial was impossible to obtain, owing to its damaged condition, but judging from the roots, it could not have been over 26, which would fail to show a greater difference than obtains between Nos. 1 and 5.

From a careful consideration of these facts it is evident that the fossil does not display a *single instance* in which it presents greater differences from the larger specimens of *Canis lupus* than do these from the smaller ones, which are admitted upon every hand to belong to the same species. For these reasons it seems to us that it is impossible to admit this fosssil to the rank of a distinct and well defined species, but it appears, in our judgment, to be but a variety which has a living representative in the mountains of Oregon, to-day. When we take into consideration the extreme variability of our American wolves, as regards size, slight peculiarities of dentition, color, etc., we gain some useful hints with reference to other specific names that have been proposed, and are taught to regard

with much circumspection and doubt, species that rest upon such characters. In this category we would place J. A. Allen's *Canis mississippiensis* from Illinois which has been proposed* upon a few limb bones, and whose only peculiarity consists in their slightly exaggerated size. As far as we are able to judge, they refer to the large variety of *Canis lupus* already considered.

UNGULATA.

The large assemblage of placental *Mammalia* included under this term may be conveniently defined as those in which the terminal phalanges are depressed in form, constituting bases of support, and not prehensile or digging organs. They are generally enclosed in a corneous epidermic covering, either partial or entire, denominated "hoofs," in contradistinction to the curved and compressed forms (claws). In the earliest Eocene period, however, according to the researches of Prof. Cope, the clawed and hoofed mammals approached one another to such a remarkable extent that with no other evidence than the ungual phalanges to depend upon, it would, in a few instances, be a difficult question to decide whether the animal was really "clawed" or "hoofed." Accepting a common origin for the two divisions, which the rapidly accumulating evidence of paleontology necessarily compels us to do, we can then understand how they have gradually diverged from the ancestral stem, and it is when the later expressions or results of this divergence are considered, our definition is most strikingly applicable.

In the history of the *Mammalia*, as evolution has proceeded, different groups have been specialized in different directions, while some retain the primitive characters of their ancestors, having undergone little or no modification. The *Primates*, beginning in the lemurs, and terminating in man, have become by far the most highly specialized in brain structure, but are primitive in other respects; the *Carnivora* have surpassed all in the development of organs specially adapted for seizing, lacerating and destroying their prey; the *Cheiroptera*, or bats, have developed members for flight; the *Rodentia* exhibit a peculiar character of the jaw articulation, together with incisor teeth specially fitted for gnawing habits; while the *Ungulata* have attained the most perfect foot structures and the greatest complexity of teeth, which naturally adapts them to modes of life and diet in which they have no competitors. It is in accordance with these various modifications that the definitions of the major groups designated "orders" are constructed.

If we had but the existing forms to consider, classification would be easy enough, but since the process of evolution has been a gradual one, each acquisition to our knowledge of the extinct fauna of the earth, sup-

* Amer. Journal Science 1876, p. 49.

plies us with forms which point towards the obliteration of established definitions, and bridge over chasms, separated in living animals by wide intervals. For this reason any system of arrangement must be looked upon as expressing the present state of our knowledge of the evolutionary processes.

In the *Ungulata* some have retained primitive characters; hence it is clear that any well directed effort looking to the internal arrangement of this group must take into consideration the structure of either the feet or teeth, or both, to sufficiently express the ordinal characters. In this respect, the teeth are of little service, since their specialization was a later production, and in all probability largely dependent upon success in the specialization of the feet. Fully impressed with the importance to be attached to the modification of the limbs, Prof. Cope has proposed to divide them into four orders,* as follows:

ORDER I. Scaphoides supported by trapezoides, and not by magnum, which supports lunar. Cuboid articulating proximally with calcaneum only. *Taxeopoda.*

ORDER II. Scaphoides supported by trapezoides, and not by magnum, which supports lunar. Cuboid extended inwards and articulating with distal face of navicular. *Proboscidea.*

ORDER III. Scaphoides supported by trapezoides, and not by magnum, which with unciform, supports lunar. Cuboid extended inwards, and articulating with astragalus. *Amblypoda.*

ORDER IV. Scaphoides supported by magnum, which, with the unciform, supports the lunar. Cuboid extended inwards so as to articulate with the astragalus. *Diplarthra.*

The first of these orders, *Taxeopoda* has but a single living representative, the African genus *Hyrax*, or as it is more familiarly known, the "cony." By far the greater proportion of the order is extinct, and belongs, so far as our present knowledge extends, to the Eocene period. The second order, *Proboscidea*, is represented by but two living genera, *Elephas* and *Loxodon*, or the Indian and African elephants respectively. The third, *Amblypoda*, is entirely extinct, and pertains to the early Eocene; while the fourth order, *Diplarthra*—corresponding to the order *Ungulata* of some authors,—is the most abundantly represented among living ungulates. It includes two distinct sub-orders, *Perissodactyla* (odd-toed), of which the horse, tapir and rhinoceros are the only living examples, and *Artiodactyla* (even-toed), of which the sheep, deer, goat, ox, camel, etc., are familiar types. Beginning in reverse order we will take up for consideration first the

*Proceedings American Philos. Society, Philadelphia, 1882, p. 444.

DIPLARTHRA.

This order includes animals ranging in size from the small chevrotains of Africa and India, but little larger than a prairie hare, to the hippopotamus and rhinoceros. The higher forms of this group represent the extreme points of departure, reached by any of the hoof-bearing series. They show the most highly specialized or perfected organization (1) in the structure of the limbs, (2) in complexity of the alimentary system, and (3) in the specialization of the molar teeth. As in almost every other group of animals, primitive types are still in existence; but these usually have a limited distribution, and are found in regions which, for sufficient reasons, it is conceivable present conditions most nearly like those of the geological age in which they reached their greatest development, and may be said properly to belong. Reasoning from analogy, however, the principal causes which appear to have been most potent in the extinction of the majority of the earlier types of this order, may be set down as (1) climatic vicissitudes with their dependent causes, and (2) incursions from carnivorous enemies. Human agencies have likewise contributed largely to the disappearance of many ungulate species from certain regions, especially in later times.

If now we reflect upon the probable causes that have led to the modification of the organs in which they show the greatest perfection of structure, it is not improbable that we may be able to discover some relation between the causes which have been influential in the extinction of the inferior types, and those sufficient to produce the modification in question. In the first place, it may be stated as a rule of pretty general application that the existing representatives of early forms of this order, viz.: *Tapirus*, *Rhinoceros*, *Suidæ* (including the pigs and peccaries) and *Hippopotamus*, are (1) polydactyle (many-toed); (2) they are lovers of swamps, marshes, or dense forests; (3) they have a comparatively simple alimentary system; and (4) their teeth present little or no modification of the simple four-lobed pattern which is the prevailing type of the middle and upper Eocene period.* Although there is no positive evidence of the fact, yet there is every reason to believe, and we are at liberty to conclude from an analogical stand-point, that these animals, during the Eocene and Miocene periods, had habits very similar, if not identical, with their near relatives of the present epoch, and were also swamp-lovers, etc. Any wide-spread physiographical changes destroying the conditions under which they had been reared, would necessarily entail one of three alternatives, viz.: migration, modification, or extinction. That extensive changes did

*The type of dentition of the rhinoceros presents a considerable advance over the others, and is more indicative of Miocene time.

take place during the Eocene and Miocene periods, causing a general drying up and disappearance of the marshes and swamps in certain regions, is now well known to geologists.

Migration was one of the alternatives of which certain species availed themselves, and finding conditions adapted to their organization, have persisted to the present day. In attempting to modify themselves to meet the requirements of the new conditions, many of those that remained perished, and their fossil remains are the only souvenirs left to attest to their former existence. Of those that have succeeded, we are not at a loss to understand more intimately the probable causes of modification. Life upon the open plain would render them more conspicuous objects, and hence, subject them more to the attacks of their carnivorous enemies. Deprived of their former means of escape, necessity compelled them to develop some defense against the ever threatening cause of their extermination. Timidity and natural instincts to escape by running, resulted in the selection and cultivation of this means. The doctrine of Cope in this matter has been thus stated by Wortman, "that in plantigrade animals (those that walk on the soles of their feet), the ends of the digits or toes describe a semi-circle, and that in the act of running the heel and wrist are raised from the ground, leaving the middle digits to sustain the weight of the body." "An infinite repetition of this posture in animals incapable of withstanding the attacks of their fierce carnivorous cotemporaries, and whose only escape was in flight, has resulted in the selection of either one or two of the middle digits, while the outer ones have either fallen into a rudimentary condition or entirely disappeared."* This has most probably taken place in accordance with the law of "use and effort," by which the organ sustaining that certain amount of pressure, strain, etc., in which the physiological waste does not exceed the amount of nutrition, grows in size and in the direction indicated by the force in question. While we do not see in any living representative of this order a plantigrade animal, yet paleontological evidence is very conclusive that their ancestors were both pentadactyle (five toed) and plantigrade, and that specialization of the limbs has consisted of the gradual reduction in the number of digits and the interlocking of the carpal and tarsal bones.

With reference to the specialization of the teeth and digestive system Wortman has likewise suggested,† "that among existing animals in which the teeth possess short crowns, with low blunt tubercles on their triturating face (the bunodont type of dentition), we observe comparatively simple digestive organs. In others, the higher ungulates, where the crowns of the teeth are greatly lengthened in a vertical direction, uniformly broadened, and the face presents a complex folding of the enamel plates (the

*Kansas City Review, 1882. Cope on the Effect of Impacts and Strains on the Feet of Mammalia, American Naturalist, 1881, p. 542.

† Kansas City Review of Science and Industry, 1882.

selenodont type), we notice more complicated digestive organs. The relations of these conditions to the character of the food upon which the respective types subsist is obvious. The bunodonts require condensed and nutritious diet for their support and are omnivorous, while the selenodonts are fitted to subsist upon food containing a smaller proportion of the nutritive elements, and of which greater quantity is required. The food of the former usually consists of nuts, berries, roots, etc., while the latter feed upon grasses and branches of trees." When forced into the open field it is evident that food of the former kind only was afforded, whence the environments of the animal immediately demanded modifications suitable to the new conditions. By the laws of use and effort, and the influence of ordinary mechanical forces, all the striking peculiarities of these animals may be accounted for.

It has been proposed by Owen to divide the order into two very natural subdivisions or sub-orders which have been defined as follows:

Astragalus truncate distally; number of toes on the hind feet odd; the median one the largest on both anterior and posterior feet; a third trochanter on femur. *Perissodactyla.*

Astragalus with distal ginglymus; number of toes even in both feet; the two median ones the largest; no third trochanter on femur. *Artiodactyla.*

Of these two groups the *Artiodactyla* is, in the present epoch, by far the more important, both in the number of species and diversity of structure. The *Perissodactyla* are now represented by but three living genera, *Equus*, *Tapirus* and *Rhinoceros*, while in the *Artiodactyla* the genera are much more numerous. In the Eocene period, however, the *Perissodactyla* exceeded them in every respect.

ARTIODACTYLA.

The early history of this group is so little known that it is impossible at present to say anything of its primitive origin. It has been traced to a very limited representation far back in the middle Eocene, but even in this early time the form of the astragalus, one of the most characteristic features in the osteology of the group, is still markedly artiodactyle. It is highly probable that they came off early from the *Taxeopoda*, but the evidence necessary to demonstrate such a supposition is as yet entirely wanting. The classification recently adopted by Prof. Flower in his article "Mammalia," in the Encyclopedia Brittanica, represents very well the state of our information on this subject. It is as follows:

Section A, Bunodonta.

Molars brachyodont (short crowned) and tuberculous; palatine bones articulated with terminal portion of maxillaries; never less than four complete toes;* no horn-cores developed on frontals; stomach imperfectly divided.

Section B, Selenodonta.

Molars hypsodont (long crowned) or brachyodont, with four crescentiform folds, whose convex surface is internal above and external below; palatines separated by a wide sinus from terminal portion of maxillaries; toes often reduced to two; with or without horn-cores; stomach divided.

These definitions, somewhat modified from those usually given, express the more striking characters observable in the *Artiodactyla* from the lowest to the highest types. Specialization or perfection of structure has taken place (1) in the development of long crowned crescented molars; (2) in the separation of the terminal portion of the maxillary bones from the palatines; (3) in the loss of incisor teeth from the premaxillary bones; (4) development of horns; (5) in the loss of the outer digits and union of the third and second metapodials into a "cannon" bone; (6) change of the odontoid process of the axis into a hollow half-cylinder; (7) co-ossification of ulna and radius with great diminution in size of the distal extremity of the former; (8) disappearance of the middle portion of the fibula, and (9) complete division of the stomach into four compartments.

Since the different steps through which these perfections have been accomplished were gradual ones, it is more than probable that, with increase of knowledge of the fossil forms, this classification will break down completely. The group *Bunodonta* includes, among living animals, the peccaries, hogs and hipopotamus, together with numerous extinct genera. Many of these latter, however, are so imperfectly known that it is impossible at this moment to indicate their exact position in the system. A classification of the living *Suidæ*, including the extinct American peccaries, appears to be most naturally accomplished as follows:

Superior canines directed downward. Terminal portion of superior maxillaries separated by a slight sinus from palatines. Glenoid cavity strongly concave from before backward, and with a well defined preglenoid crest. *Dicotylinæ* (Peccaries).

Superior canines directed upward. Terminal portion of maxillaries united with palatines. Teeth without cement. Angular process of mandible slightly or not at all deflected. Glenoid cavity slightly convex from before backward, and without preglenoid crest. *Suinae* (True swine.)

Dentition extremely aberrant. Incisors in young individuals two above

*Entelodon, a Miocene genus, according to Kowalevfsky, had only two toes.

on each side and three below. Molars reduced in old individuals to last true molar, which is greatly elongated and composed of three longitudinal rows of columnar tubercles, having the valleys occupied with a thick deposit of cementum. Superior canines directed upward. Distal portion of maxillaries articulating with palatines. Angular process of mandible not deflected. Glenoid cavity convex from before backward, and without preglenoid crest. *Phacochœrinæ* (Wart hogs.)

This last group includes as yet but a single genus, *Phacochœrus*, with two species confined to the tropical regions of Africa. They present a peculiar modification of the teeth analogous to that of the elephants. The second sub-family, *Suinæ*, is represented in the present epoch by three living genera *Sus*, *Potamochœrus* and *Babirussa* containing eight species which range over Europe, Asia, Northeast Africa and the East India Islands. The *Dicotylinæ*, on the other hand, are confined exclusively to North and South America.* The sub-family includes two living and at least twelve extinct species, grouped into five genera.

DICOTYLINÆ.

Synopsis of genera.

Three premolars in the upper jaw, with single external and internal lobes. A wide diastema between the anterior one and its successor. With one species from Miocene of Oregon. *Chænohyus*, Cope.

Upper premolars four, with single external and internal lobes. Lower premolars four. A diastema before and behind the first. With three species Miocene of Oregon. *Thinohyus*, Marsh.

Premolars four above and below without diastemata. Last (4th) upper premolar with two external and one internal tubercle. Miocene of Europe and America. *Hyotherium*, Meyer.

Premolars three above and three below, with single external and internal lobes. Wide diastemata between premolars and canines. With two species Post-Pliocene of America. *Platygonus*, Le Conte.

Premolars three above and three below. Fourth upper and third and fourth lower premolars like first true molar, with four lobes. Wide diastemata between canines and premolars. *Dicotyles*, Cuvier.

****Hyotherium*, which is arranged here, is also found fossil in Europe.**

DICOTYLES, Cuvier.

The species of this genus, so far as known, are susceptible of definition in the following manner:

Upper incisors cutting, with posterior cingula on crowns; the median pair the larger. A slight depression in front of and beneath the orbit. No maxillary ledge above first and second premolars.
Dicotyles torquatus, Collared Peccary (living.)

Incisors cutting and without posterior cingula; median pair the larger. No preorbital depression. Infraorbital foramen situated above first upper true molar. A strong maxillary ledge above first and second premolars. Canines more robust. Species larger. Length of diastema above equal to length of superior premolars.
Dicotyles labiatus, White-lipped Peccary (living.)

Upper incisors and diastemata unknown. Superior molars and premolars curved outwardly, and not straight, as in the other species. About one-half the bulk of *Dicotyles torquatus*.
Dicotyles hesperius, Marsh (extinct.)

Upper incisors and diastemata unknown. Equaling in size *Dicotyles labiatus*. Enamel of the crowns of the molars without wrinkles and minor tubercles as in the living species. *Dicotyles pristinus*, Leidy, (extinct.)

Upper incisors sub-equal and conic. Length of the diastema of the upper jaw greatly exceeding that of premolars. Second superior premolars without anterior or posterior cingula. No maxillary ledge. Species slightly larger than the last. *Dicotyles nasutus*, Leidy (extinct).

Upper incisors, unknown. Lower incisors, three. Diastema in lower jaw, equaling in length the lower premolar and first true molar combined. Last upper molar, one-third longer than penultimate one. Enamel without wrinkles and devoid of external and internal cingula. First, inferior premolar, with rudimental anterior cingulum. Size, about one-fourth larger than *D. labiatus*. Canines relatively small.
Dicotyles condoni, Marsh (extinct).

Of the species above enumerated and defined, two are living and the rest are extinct. The first, *Dicotyles torquatus* or the "collared peccary," is commonly known as the "wild hog" in southwestern United States, and ranges from southern Arkansas to Paraguay in South America. The animal is as large as a small-sized hog, which it otherwise resembles very much in external appearance. The "white lipped peccary" is somewhat larger, and is confined to the dense forests of South America.

The third species, *hesperius*, was described by Prof. Marsh, in American

Journal of Science and Arts for July, 1871, from specimens submitted to his examination by Prof. Thomas Condon, of the University of Oregon, found by him in the Loup Fork bed of the John Day Valley, Oregon.

The fourth species, *D. pristinus*, was described by Dr. Leidy, from a few teeth found in the Loup Fork beds of Oregon, in the same locality as the last. For a knowledge of this species we are likewise indebted to Prof. Condon, its discoverer. Upon the acquisition of more perfect material this species may yet prove identical with either *D. labiatus* or *D. nasutus*. The characters upon which the species was proposed do not appear to be very striking, and may pertain to individual variation only.

The fifth species, *D. nasutus*, is likewise extinct. It was first described by Dr. Leidy in the Proceedings of the Academy, Philadelphia for 1868, p. 230, from material placed in his hands by the late Dr. David Dale Owen, a gentlemen whose name will long be remembered in connection with geologic science, for his scholarly attainments and his energy in bringing to light many rare and interesting specimens of fossil remains. "The specimen consists of the fore-part of the upper jaw, containing on one side the canine and anterior two premolar teeth. It also retains the socket of the other canine and those of the incisors, one of which is likewise preserved." It was obtained at a depth of between thirty and forty feet in digging a well in Gibson county, Indiana, and is figured by Dr. Leidy in his "Extinct Mammalian Fauna of Dakota and Nebraska." The principal characters, as far as we are able to learn from the fragmentary specimens, have already been given.

The last species is *Dicotyles condoni*. This species was originally described by Prof. Marsh in American Journal Science for 1871, under the name *Platygonus condoni*, with a question. A number of teeth from the same locality which agree with Prof. Marsh's description have lately come under our inspection. The premolars display the characters of the genus *Dicotyles* instead of those of *Platygonus*. The species which was described by Prof. Cope, from the Loup Fork beds of Nebraska, under the name *Dicotyles serus*, probably pertains to this species. This determination was based upon the lower jaw alone, while the original *D. condoni* was described from the upper molars. Among the specimens of this latter species from Oregon, which are now preserved in Prof. Cope's collection of vertebrate remains, there is a last lower molar associated with the molar teeth of the upper jaw. The size and details o structure of this last inferior tooth agrees perfectly with the corresponding tooth of the type of *D. serus*. For this reason and until we know the upper teeth of *D. serus*, it is proper to regard them as identical.

Another species has been described by Dr. Leidy, under the name *Dicotyles lenis*, from a few isolated teeth found in the Southern States. After having inspected carefully the type specimens upon which this species was proposed, and taking into consideration the amount of individual

variability seen in the dentition and osteology of the species, which it is said to most resemble, *Dicotyles torquatus*, we must conclude that it is too imperfectly known to rank as a species. The characters upon which the species rests obtain equally well as individual variations of the collared peccary, *D. torquatus*. The next genus is

PLATYGONUS, Le Conte.

Two species are certainly known.

Last upper molar with cingula continuous, or nearly so, around the base of the crown. Inner cingula of upper molars strong and well defined. *Platygonus compressus*.

Last upper molar without internal or posterior cingula. Inner cingula of upper true molars rudimentary or wanting. Species almost one-third larger than first. *Platygonus vetus*.

PLATYGONUS COMPRESSUS, Le Conte.

Plate 1.

This animal is indicated in the Indiana collection by the anterior or symphysial portion of the mandible, with a considerable part of the left ramus attached, supporting all the premolar and molar teeth, except the last. According to the label which it bears, it was derived from Laketon, Wabash county, Indiana. Numerous remains of the same species occur in the vicinity of Galena, Ill., from which place Dr. Le Conte obtained the specimens upon which the original description of the genus and species was founded. Dr. Leidy has recently exhibited before the Philadelphia Academy two almost complete skeletons of the same species obtained in the State of New York. A beautiful and complete skull, deposited by the American Philosophical Society, is now preserved in the museum of the Academy of Philadelphia. It was found in a cave in the State of Kentucky as early as 1805, but was not known to represent a distinct genus until some years later, when brought to the notice of Dr. Leidy. The remains above enumerated, together with numerous fragments of teeth and bones of various parts of the skeleton, preserved in different collections, constitute the material that has so far been recovered, and upon which our knowledge of this extinct quadruped depends.

In size they indicate an animal as large as a common sized hog, but of more slender proportions. The animal was probably a fair runner, and had habits similar to the living peccaries, if analogy furnishes us any basis for judgment. Its range must have been from the Canada border on the north to the Gulf of Mexico south, and in all probability extended from the Missouri river on the west to the Atlantic. *Platygonus vetus* was much larger, but is known from a few fragments only that were obtained in a bone cave in Pennsylvania. Two other species have been described

by Prof. Marsh in Amer. Journal Science for 1871. The first of these, *Platygonus ziegleri* was obtained from the Bridger Eocene of Wyoming. It is much more probable that the few teeth which Prof. Marsh has referred to this genus pertains to some other. If, indeed, they do pertain to the genus *Platygonus*, they indicate a most remarkable history for it. We choose to regard the evidence as too imperfect for such a determination. The other species, *P. striatus*, described at the same time, was established upon a few teeth from the Loup Fork of Nebraska. The characters upon which this species was proposed, are of the most trifling and variable kind, and are otherwise too fragmentary to be entitled to recognition.

Having concluded a mention of the species included in the *Bunodonta*, we come next to a consideration of the higher group, or selenodont division of the sub-order. Until more is known of the structure of the Miocene representatives of this division it is difficult, if not impossible, to express in a system of classification their exact relations. For this reason we will not attempt at present to indicate their arrangement. However there appear to be two branches, if not three or four, that have been sufficiently differentiated from the primitive stock to rank as primary divisions of the *Selenodonta*.

The first of these is the *Ruminantia*, including such animals as the ox, sheep, goat, deer, giraffe, etc., which are distinguished by the coossification of the third and fourth metapodials into a "cannon bone," usually by the presence of horn-cores on the frontals, by being entirely digitigrade and finally by the complete loss of the incisors from the premaxillary bones.

The second *Tylopoda*, including the camels and llamas, are devoid of horns; they have the arches perforated by the vertebral canal in the cervical vertebræ instead of the transverse processes as in the *Ruminantia*. They walk upon the plantar and palmar surfaces of the phalanges; and finally they have at least one incisor upon each side in the premaxillaries.

The relations of the chevrotain group to the extinct *Anoplotheriidæ* of Europe and the *Oreodontidæ* of America have been decided in favor of the latter, from which they possibly descended, but it is probable that two more primary subdivisions will be recognized. However this may be, we are at present concerned with the first division only.

RUMINANTIA.

Prof. Flower remarks: "The *Pecora*, or true Ruminants, form at the present time an extremely homogeneous group, one of the best defined and most closely united of all the *Mammalia*. But, though the original or common type has never been departed from in essentials, variation has been very active among them within certain limits, and the great difficulty which all zoologists have felt in subdividing them into natural minor groups arises from the fact that the changes in different organs

(feet, skull, frontal appendages, teeth, cutaneous glands, etc.) have proceeded with such apparent irregularity and absence of correlation that the different modifications of these parts are most variously combined in different members of the group. It appears, however, extremely probable that they soon branched into two main types, represented in the present day by the *Cervidæ* and the *Bovidæ*—otherwise, the antlered and the horned ruminants. Intermediate smaller branches produced the existing musk-deer, giraffe, etc."

In the antlered division, the horns consist of outgrowths of osseous material from the frontal bones of the skull, covered in the growing state by a highly vascular and sensitive integument, which, upon completion of the antler, dies and peels off. After a time absorption occurs, when the horns are shed, to be renewed by the same process.

In the giraffe, the horns are united to the skull over the coronal suture, or junction of the frontal with the parietal bones, as epiphyses, and are permanently covered with a hairy integument. The horn-cores are finally anchylosed with the cranial bones, and are never shed.

In the group with true horns, the bony cores are outgrowths from the frontal bones with which they are always firmly united, and are covered by an integument modified into a dense corneous sheath. Their classification with appropriate definitions would, therefore, be indicated as follows:

Frontal appendages when present in the form of antlers. Molars brachyodont, with little cement. Two orifices usually to lachrymal duct. Lachrymal bone not articulating with nasal. An anteorbital pit and vacuity. (Flower.) *Cervidæ*, (Deer.)

Frontal appendages consisting of a pair of short, erect bony processes ossified from distinct centres, and afterward united to frontals by anchylosis. Horns covered with hairy integument. Molars brachyodont, and without cement. *Camelopardalidæ*, (Giraffe.)

Frontal appendages when present in the form of permanent horns. Molars hypsodont. Usually one orifice to lachrymal. Lachrymal bone articulating with nasal. No vacuity or anteorbital pit. Molars with cementum. *Bovidæ*, (Sheep, Ox, Goat, Antelope, etc.)

Of the first family, *Cervidæ*, there is represented in the collection a species which was described by Prof. Cope, in Bulletin U. S. Geol. Surv. Territories, Vol. IV, 1878, under the name

CARIACUS DOLICHOPSIS, Cope.

Plate 2.

The following description was given: "John Collett, of the Geological Survey of Indiana, discovered in a late lacustrine deposit in Harrison county, Indiana, a number of Post-Pliocene fossils. One of these

is the ulno-radius, etc., of a *Bos*, and the other is the left mandibular ramus of a deer, probably of the genus *Cariacus*. The jaw differs in its proportions from those of *C. virginianus* (the common Virginia deer), *C. macrotis* (the "mule deer" of the Rocky Mountains), and *C. columbianus* (the "black-tailed" deer of the Cascade Mountains), with a considerable number of which I have compared it. It belonged to an animal of the average size of *C. virginianus*, but differs in having the diastema an inch or so longer, while the tooth line is shorter. Placing the first molars in line, the last molar of the fossil form attains only the penultimate column of that of the *C. virginianus*; in some cases just a little further. On the other hand, the angle of the mandible extends beyond that of *C. virginianus*, and the slope of the anterior base of the coronoid process is more gradual. At the same time this portion is less oblique in a transverse direction, owing to the prominence of the external face of the ramus. The ramus differs also in the great prominence and anterior position of the posterior edge of the masseteric fossa, which leaves behind it a wide oblique face, little developed in the existing species."

Additional observations and comparisons serve to confirm the validity of the species above described. The jaw differs widely from that of the Reindeer (*Rangifer tarandus*), in the shorter length of the dental series, and especially in the larger size and greater width of the true molars. The diastema is shorter than in the Reindeer. It differs most remarkably from all other species with which we have been able to compare it, in the character of the angle of the mandible. Beside the peculiar space behind the edge of the masseteric fossa already mentioned, the angle is considerably thickened and beveled from without inward. The posterior border of the ascending ramus, instead of descending with a gentle curve outward to its junction with the angle, as in all the species above mentioned, descends almost perpendicularly to meet the angular process, with which it forms a distinct ledge.

Measurements.

	M.
Horizontal length of ramus from alveolar border	0.250
Length to first molar	0.100
Length of symphysis	0.047
Length of dental series	0.085
Length of premolars	0.034
Length of base of ascending ramus	0.058
Elevation of condyle	0.075
Length of base of coronoid process	0.021
Width of coronoid	0.021
Width of last molar	0.011
Length of last molar	0.021

Length of third premolar	0.011
Depth of ramus just behind symphysis	0.016
Depth of ramus at first molar	0.026
Depth of ramus at last molar	0.028

The collection likewise contains the greater portion of the right superior maxillary bone of a cervine animal bearing all the teeth with the exception of the last molar. It is highly probable that it pertains to the same species, but of this we can not be certain. The teeth resemble very closely those of the Virginia deer (*C. Virginianus*), and agree perfectly in size with an average size individual of this species.

The third family, *Bovidæ*, is represented by the distal part of an humerus only, which is referable to the living species of American bison (*Bison americanus*). It is, however, more than probable that the musk ox, *Ovibos*, of which two extinct species are known, *O. cavifrons* and *O. bombifrons*, inhabited the State during this period. Their remains are not uncommon in the drifts, peat-bogs, etc., in the States of the great interior basin. They ranged as far south as Arkansas, and probably to the Gulf.

Still another species of this family gives to the fauna an unfamiliar aspect, the largest and most powerful artiodactyle known to occur within the borders of Indiana. Its remains have also been obtained in the adjoining States, Ohio and Kentucky.* This is the *Bison latifrons* of Leidy. The species is known from a tolerably perfect skull from Texas preserved in the British Museum, as well as various crania and fragmentary remains of jaws, teeth, limb-bones, vertebræ, etc., most of which are contained in the collection of the Academy of Natural Science, Philadelphia. The chief peculiarities of the animal are its large size and immense expanse of horns. It was as large at least as the Indian buffalo (*Bubalus arni*) or arnee, which attains a size one-third greater than our American bison. The position of its horns, however, indicate its affinity and reference to the genus *Bison*.† The horn-cores measure twenty-one inches in circumference at the base, and the horns were upwards of four feet in length in the largest individuals. The horns differ from those of the arnee in being circular, instead of triangular in section, as in that animal. The length of horn attained by the arnee, however, is stated to be, in some instances, as much as six feet for each horn. From this species we pass to the second suborder of the *Diplarthra*.

* Remains of *B. latifrons* are found in Vanderburg county. COLLETT.

† It is proper to observe in this connection that *Bison* differs from *Bos* in having the horn-cores placed somewhat in advance of the occipital crest.

PERISSODACTYLA.

As has already been mentioned, this group has in the present epoch but a limited representation, and is confined to three families, with few genera and few species. Two of these families, the *Rhinocerontidæ* and the *Tapiridæ*, are remnants of groups that attained their greatest development, both as regards numbers and diversity of structure, far back in the shadowy past. By inhabiting confined areas and favored localities, which present conditions most adapted to the state of development of their various organs, they have in a measure been granted immunity from an excessive severity of the struggle for existence, and although inferior, continue to represent their primeval brethren. It is thus from the evidence which paleontology furnishes that the philosophic and systematic naturalist is able to place within easy grasp of the understanding the systematic position, both in time and rank, of many living creatures that have been stumbling blocks to a less comprehensive knowledge of the many extinct groups of organized beings. But a single family of this sub-order, the *Equidæ*, or horses, really pertains, by virtue of their superior organization, to the present epoch, and the history of the various steps by which they have accomplished this degree of perfection is intensely interesting, and will be discussed further on. The group which first claims our attention is the

TAPIRIDÆ.

The earliest known appearance of this family is in the beginning of the Miocene period. Many Tapiroid animals, however, are found in strata of Eocene age, from which it is highly probable that the true tapirs were derived. The living species are grouped into two genera *Tapirus* and *Elasmognathus*. Besides these there have been two fossil genera described, one of which is clearly referable to this family. The one about which doubt exists is *Tapirulus* of Gervais, established upon a few molar teeth from beds of Oligocene (Lowest Miocene) age. The genus established by Prof. Marsh* under the name *Tapiravus* is only known from his description, which is characteristically brief. Leaving out the questionable genus *Tapirulus*, the remaining ones will be defined as follows:

Third and fourth upper premolar, only like first true molar. *Desmatotherium.*

First upper premolar only different from first true molar; no heel on last inferior molar; nasal septum cartilaginous. *Tapirus.*

Teeth as in *Tapirus*; nasal septum osseous. *Elasmognathus.*

*American Journal of Science and Arts, Vol. xiv., 1877, p. 252.

Tapirus, Cuvier.

The living species of this genus are limited, with one exception, to the western hemisphere. The Malayan tapir, *T. malayanus*, forms this exception. It inhabits Farther India and the East India Islands. There are at least two well-marked species found in South America, together with two others from the Panama Isthmus, removed by Gill into a distinct genus, *Elasmognathus*, which he has created for their reception. The most common of the American species is the *T. terrestris*, or *americanus*, as it is often called, which is widely distributed in South America, east of the Andes mountains. A second species, *T. villosus*, is found high up on the mountain slopes of British Columbia and Ecuador. It is commonly known as the hairy tapir and is distinguished from *T. terrestris* by being covered by a heavier coat of hair, and other peculiarities.

Tapirus terrestris was quite abundant in North America during the Post-Pliocene period; its remains occur frequently as far north as Pennsylvania, and it is probably to this species that the fragments obtained by Mr. Francis A. Lincke, near Evansville, Indiana, in association with those of the wolf already mentioned, pertain. Another species has been described by Dr. Leidy under the specific name of *haysii*. This species, it may be remarked, rests upon size alone (a very unsafe guide), it being somewhat more robust than the *terrestris*. It is difficult at present, with the fragmentary material at our disposal, to say really whether it pertains to a group of individuals characterized by a more robust size than *T. terrestris*, or whether it is merely an individual variation of this species.

Equidæ (Horses).

There has probably been no animal brought into a state of domestication by man, which has proved a more constant companion to him, or has rendered a greater amount of assistance in the growth and spread of civilization than the horse. Possessed of a kind, gentle and even-tempered disposition, which few animals of like proportions display, together with strength and powers of endurance, he is peculiarly adapted to the important station he occupies. So indispensable, indeed, has this animal become that without his continued assistance many of the most important industries of which civilization boasts must have ceased or been greatly retarded.

The existing horses are best classified in a single genus, *Equus*, containing at least six species, as commonly accepted by authors. Their distribution is now most extensive, two of them having been introduced by man into every region where civilization exists. The domestication of the common species, *E. caballus*, together with the most rigid practices of artificial selection in its cultivation, has resulted in the production of a

number of permanent varieties (breeds), some of which are quite as distinct from the original stock and from each other as are the various species in a wild or feral state.

Many of these breeds may now, with a considerable show of logic, be properly regarded as incipient or more or less distinct species. The fact that many, if not all of the so-called "thoroughbreds," when properly united transmit to their offspring the peculiarities of their race, such as speed, size, color, form, powers of endurance, etc., or in other words, the fact that there is a marked and constant tendency to breed true to their kind is well known to those who are accustomed to study the subject. Examples of this kind can be found upon every hand. The Shetland ponies breed true to their small size, and shaggy manes and tails. The Norman Percherons of France are also well known to breed true to their large size, heavy bone, general robust form, as well as peculiarity of color, when the male and female of pure blood are united. Certain breeds of Andalusian horses from Spain are characterized by large heads, beautiful leopard-like spots, and very scant manes and tails, which characters they will transmit with unerring certainty.

The different breeds of racers and trotters are well known to be possessed of qualities of speed and endurance equaled by no other. The offspring of pure strains of these racers are always known to horsemen by their lithe and beautiful forms, and are certain to display the characteristics of the breed by their activity, speed and endurance. It is from their numbers that all the famous horses distinguished for their running and trotting qualities have been derived.

The argument that has been used against the doctrine of evolution, as accounting for the origin of species, urges the inconstancy and general instability of these artificial products when abandoned to the natural environments and conditions to which wild species are subjected. It is highly probable, and no doubt true, that they will, in many instances, revert to the primitive stock from which they have been derived; but this fact, admitting it to be invariably true, is of no significance, and proves nothing. It must be borne in mind that permanent variations, or departures from the original type, whenever the result of artificial selection and special artificial conditions, constantly require these conditions to be maintained. In other words, their peculiarities mean simply adaptations to certain environments, and are the result of accumulation of an infinite number of slight variations in a given direction, rigidly selected with the view of making them conform to a certain desired standard of excellence. This has required special favorable conditions for its accomplishment. It has never been urged by evolutionists that wild species have been the result of artificial selection. The only fact of importance connected with it, is, that animals in a state of domestication, may be made to vary to such an extent, the varieties having a tendency to remain permanent as long as

surrounded with certain conditions, as to resemble very closely the products of nature in every essential and important character.

If now we ask ourselves what a species is, and we answer the question (as a large majority of naturalists at the present day do), that it is the product or simple aggregation of a large number of minute individual differences as size, color, anatomical peculiarities, etc., so intensified as to become permanent, we are not at a loss to understand the true significance of the breed characters of our domestic animals. We must conclude that they are the same thing produced only under appropriate circumstances.

Respecting the existence of the horse upon the American continent at the time of its first discovery by European explorers, there is a widely accepted opinion among naturalists generally, that it was entirely extinct, and that the vast herds of wild horses subsequently seen roaming over the South American pampas, were derived from the horses which the Spaniards brought over with them when the country was colonized.

Upon this question, however, Mr. E. R. Berthoud has, in Kansas City Review, thrown considerable doubt. Having had occasion to examine the records of discovery and maps of Cabot, the Spanish explorer, he says: "It is an incontestable fact that Cabot went in 1527 to the east coast of South America on an exploring voyage; that he discovered the rivers La Plata and Parana, and explored them some distance inland, returning to Spain in 1530.

"Upon examining that map, I find that the Rio La Plata was explored up to the 25th parallel of north latitude, and Spanish names were given to its branches and all prominent points; and in addition he has marked on the map pictures of natives, prominent animals, and some trees, and that at the head of the La Plata, with the puma and parrot, and perhaps the condor, he has given the horse as apparently a quadruped that existed then on those vast plains of the *Gran Chaco*, where to-day they roam in countless herds. It may be claimed that this is not proof of their native origin; but we claim that it is a fair presumption, for neither Spaniards in Peru or other parts of America, nor even Portuguese, had been long enough in South America for the few Spanish horses introduced to have roamed wild from Peru to the head of the Paraguay and Parana rivers, and increased in numbers sufficiently to have attracted the attention of the Spanish explorers. The period was too short, and the distance too great from the Spanish possessions in Peru, across the vast forests of the Andes, for such a rapid increase. We can reconcile this discrepancy only by believing that the paternity of the vast herds of the Argentine Republic and Paraguay was a native breed of American horses, mixing afterward with the Spanish breed introduced by the conquerors. Not twenty years had passed between the discovery of Peru and the discovery of the Rio La Plata."

Presumptive evidence of a very striking nature can be drawn from

paleontology to support the conclusions reached by Mr. Berthoud. For example, the remains of an animal which is indistinguishable from the existing domestic horse, occur in beds of Post-Pliocene age over a large part of the United States, and come so near to the Recent period that it is often difficult, if not impossible, to say definitely whether they are the remains of horses introduced into this country by the Europeans, or whether they pertain to an indigenous stock. In some instances, however, it is perfectly clear that they pertain to a native breed. Supposing therefore (as there are good reasons for doing) that the physical conditions of the continent were nearly the same toward the close of the Post-Pliocene period as they now are, and seeing that the present conditions are so admirably adapted to the support and multiplication of what is to all appearances the same species, we are at a loss to understand what would cause its extinction. As in the case of the llama, driven south by glacial cold, they probably entered South America, and it is in this region we would most reasonably expect to find them. It is by no means an established fact, however, that the horse was not cotemporary with man upon the North American continent.*

The horse is one of the few animals the genealogy and geological history of which is now completely known. All the successive links necessary to demonstrate its ancestry are found in this country in strata ranging from the early Eocene to the present. For a full discussion of this question, however, we must refer the reader to publications by the senior author in the Paleontology of the Wheeler Survey, vol. IV, 1877, and by the junior author in "Kansas City Review" for 1882 (republished in "Revue Scientifique," Paris, 1883), "On the Origin and Development of Existing Horses."

PROBOSCIDEA. (Elephants and Mastodons.)

The definition of this order has already been given. It includes within its limits animals most gigantic in size of all the terrestrial *Mammalia;* and if we are able to interpret correctly the affinities and relationship of mammals generally from osteological evidence, they have had a long and eventful career, dating their existence from a very remote period of the earth's history. The peculiar modification of certain of their organs, as well as their general unique appearance, has been instrumental in misleading systematic writers on this subject, to a proper conception of their correct position in the scale of animal organization.

The recent interesting discoveries of Cope have placed within reach of our understanding a more definite knowledge of the primitive condition of the ungulates in general; and with this knowledge in view, we are en-

*See Cope, Proceedings Academy Natural Sciences, Philadelphia, 1882, p. 291.

abled to understand in what particulars these animals retain primitive characters, and in what they are specialized. Thus, in the structure and manner of replacement of the teeth, together with the possession of a proboscis and certain modifications of the skull and incisor teeth, they are highly specialized, while on the other hand in the structure of the limbs, and as Prof. Flower remarks, "in the presence of the two anterior venæ cavæ," as well as other features, they retain a primitive condition. The generalized character of the limbs is seen, in the anterior ones, in the complete separation of the ulna and radius, the serial arrangement of the carpal bones,* and the possession of five fully-developed toes; in the posterior members, in the absence of a *ligamentum teres* of the femur, the freedom of the tibia and fibula, the partial non-interlocking of the tarsal bones, and likewise in the possession of five toes.

The structure and method of replacement of the teeth in the later representatives of the *Proboscidea* is quite curious, and indicates a wide departure from the primitive condition, but fortunately we are now able to supply the intermediate links which have preceded the highly specialized ones in time, and gain some useful hints, if not positive knowledge, of the steps by which this specialization has been reached.

As already indicated, one of the most interesting peculiarities connected with their dentition is found in the method of replacement of the grinding teeth. By the way of general information, it may be stated that in a large majority of the *Mammalia* there are two sets of teeth, denominated the *deciduous*, or *milk* dentition, and the *permanent* dentition. The deciduous teeth are always fewer in number than the permanent ones, and are displaced by vertical growth of the permanent set. Now of the grinding teeth, or those situated behind the canines, those that displace or vertically succeed milk molars, are termed *premolars*,† while those that do not have any deciduous predecessors are termed *true molars*. In most, if not all, the diphydont *Mammalia* (those that have two sets of teeth), the difference in the period of eruption of the permanent teeth is very constant, making the disparity in the amount of wear sustained by the individual teeth a conspicuous feature, and serving as a useful guide in the determination of the molar and premolar series in both recent and extinct mammals. It is proper to remark here that the dentition in the *Batrachia* and *Reptilia* consists of not one or two sets, as in the *Mammalia*, but the teeth are replaced by vertical successors to an indefinite extent. As fast as a tooth is worn out a new one takes its place from beneath. If we look

*By serial arrangement is meant the super-position of those of the proximal row (viz.: Scaphoides, semilunar, cuneiform), directly upon those of the distal row (viz.: Trapezium, rapezoid, magnum, unciform). Thus the unciform supports the cuneiform only, the magnum, the lunar, and the trapezoid the scaphoid. In the *Diplarthra* the bones of the two rows interlock or alternate.

†Sometimes there is a failure, in ordinary diphydont mammals, for the first premolar to be succeeded, in which case it is a persistent milk molar.

upon the *Reptilia* as the ancestors of the Mammalia (for which there appear to be good reasons), it is clear that the diphydont dentition is the more primitive of the two, as far as replacement is concerned. In the living representative of this order, *Elephas* and *Loxodon*, or the Indian and African elephants, the teeth do not succeed one another in a vertical direction, but come in from behind forward. The individual teeth are so large that no more than one or parts of two are in use at the same time in each jaw. The molar teeth are seven in number upon each side in either jaw (the normal number), but it not unfrequently happens that the two anterior ones are shed early in life. There is never any vertical displacement of any teeth. For this reason it appears that the four anterior grinders are persistent milk molars, while the three posterior ones represent the true molars of the ordinary mammal.

As we pass backward a step in geologic history, we meet with the remains of an animal of elephantine proportions which, as we are able to judge from analogy, presented the external appearance and peculiarities of the existing species; this is the genus *Mastodon*, which furnishes us with an important intermediate link. It was pointed out by Owen as early as 1846, that the first and second grinders, both in the upper and lower series, were succeeded by teeth developed in the jaw above and below as ordinarily observed. Another step backward in time brings us to the *Dinotherium*, the earliest true proboscidean known. In this animal the deciduous or milk teeth were all replaced in the normal method. From these facts we are able to learn that the complete suppression of the four premolars of the adult dentition was accomplished by a series of gradual steps, and that it began at the posterior end.

The structure of the molar teeth next demands consideration. If the adult worn tooth of an Indian elephant, *Elephas indicus*, be examined, the grinding surface will be seen to consist of a number of greatly flattened elliptical areas of dentine, bordered by vertical laminæ or plates of enamel, which have a more or less crimped appearance. These will be found to be comparatively of great depth, connected at the base, and having the intervening spaces as well as the outside covered by a thick deposit of cementum. The number of these elliptical areas or ridges (for such indeed they may be properly regarded, with their tops worn down by attrition) vary in the different teeth as we pass from before backward. The average number for the six successional teeth beginning with the second, is given by Prof. Flower as 4, 8, 12, 12, 16, 24.

In the African elephant, *Loxodon africanus*, the ridges are fewer in number and so thickened in their middle portion as to give to the dentinal areas a lozenge-shaped appearance when worn. The enamel plates are likewise much thicker and less crimped than in the Indian species. The "ridge formula" is given by the same author as 3, 6, 7, 7, 8, 10.

In the genus *Mastodon*, the ridges are always still fewer in number,

never exceeding five; and there is no thick deposit of cementum in the valleys and upon the exterior as in the teeth of the other two genera. The mamillary projections into which the ridges are often divided has given the name to the genus, *mastodon* meaning "nipple tooth." The absence of the cementum causing the wide gaping valleys between the ridges gives to the teeth a very different aspect, and one would scarcely suspect that they had much relationship with the elephants, did he not know of the many intermediate and connecting links between them. Owing to the smaller size of the individual teeth, there were sometimes three in use in each jaw at one time.

The molar dentition of *Dinotherium* presents nothing peculiar in its structure. As already observed, the premolars succeed milk molars in the manner of the ordinary mammalian dentition. The true molars are still more simplified, resembling very strongly those of the tapirs and lophiodons, with only two cross crests or ridges, except in the first true molar, where there are three. In all the genera except the last, two incisors are enormously developed, forming the so-called "tusks" in the males; they are of small size, or entirely wanting in the females. In the males of the mastodons, small tusks are not unfrequently found in the lower jaw as well. In *Dinotherium* on the other hand the tusks are apparently absent from the premaxillaries, but are compensated for by the appearance of two strong decurved tusks in the lower jaw.

Of the order *Proboscidea*, remains of two species occur in Indiana, the first of which is referable to

ELEPHAS PRIMIGENIUS, Blum. (Mammoth).

Plate 6, *Figs.* 2, 3, 4, 5.

This species, which is essentially an elephant, and therefore referable to the genus *Elephas*, finds its nearest relative in the Indian species, *E. indicus.* It is indicated in the collection by several molar teeth, one of which is shown in Pl. 6. Another tooth of this species was presented to the museum of the Philad. Acad. Sciences, where it is now preserved, by Dr. Hallowell, which he obtained in Madison, Ind.

This is one of the few extinct animals the structure of which is thoroughly known. The finding from time to time of more or less complete carcasses in the frozen soils and ice cliffs of Siberia, is so familiar to every one as to need no repetition here. It is well known to have possessed a very dense covering of hair, whence the appellation "Hairy Mammoth." Besides the abundance of this hairy coat, the species differs from its Indian relative, in the character of the molar teeth, by their greater breadth as compared to their length, by the narrowness of the dentinal areas and consequent crowding of the enamel plates, and finally by the coarseness of the "crimping" which is so fine in the *E. indicus.* The tusks were very large and had a tendency to a spiral twist, a condition peculiar to the

species. There are two well marked varieties of this species, both of which appear to have been represented in America. Those in which the transverse plates of enamel are very thin, are known as the "thin plated variety," and those in which the plates are thicker are known as the "coarse plated variety," approaching in this respect the *Elephas antiquus* of Europe. These varieties are sometimes regarded as distinct species, but owing to the intermediate conditions discoverable between them, this determination is materially weakened if not altogether invalidated.

The size of the mammoth was about one-third greater than its living congener, *E. indicus*, whose average height does not exceed nine feet. By the possession of a dense covering of hair and under-wool it was fitted to inhabit higher latitudes; and indeed, that northern Siberia was the great theater where countless hordes of this mighty monster roamed at will, is attested by the numerous remains that have been left in the Post-Pliocene deposits of that region. So numerous and well preserved are these remains, that ivory furnished by the tusks of the mammoth has formed a regular export from the country since the beginning of the tenth century.

The thin plated variety appears to belong to the northern latitudes and is best known; while the coarse-plated variety (*Elephas columbi*, Falc.), in this country at least, comes from the southern portions of the United States. It is impossible to say whether or not it was likewise covered with a woolly coat as was the northern variety; but if it be true that its habitat was in tropical or sub-tropical regions, the inference that it was not, seems well grounded. All that we will ever be able to know of the habits of these creatures must be inferential. Thus we are perfectly safe in assuming that they were exclusively herbivorous, and were doubtless gregarious to a certain extent. In view of the great development of the tusks in connection with the shortness of the neck, neither of which would permit the mouth to reach the ground, they must have obtained their food by means of a proboscis, as in the existing species.

Mastodon americanus, Blum.

Plate 3, *Figs.* 1, 2; *Plate* 6, *Fig.* 1.

Of the characters of this genus already mentioned, the principal ones are the simplified form of the molar teeth as compared with the elephants, and the replacement of some of the milk molars by permanent premolars growing in a vertical direction. Many transitional forms, however, are known which establish a close connection with both the genera *Loxodon* and *Elephas*. It is doubtful whether more than one species has so far been found in the Post-Pliocene deposits of this country, notwithstanding the fact that several have been described. The imperfect remains upon which the paleontologist must frequently form judgment, together with the individual variability of the teeth, no doubt caused by their large

size, makes it a matter often of considerable difficulty to decide upon their validity. In this case, however, it seems best in our judgment to regard the Post-Pliocene fcrms as constituting but a single species. This one is represented in the collection by several molar teeth belonging to both jaws. They agree in every respect with the corresponding teeth of *Mastodon americanus*, to which, without question, they are referable.

In general the mastodons resemble the elephants very closely as far as their osteology is concerned, and, indeed, they may justly be regarded as a more ancient and primitive type of this modification of the ancestral mammal. In size the species are both smaller and larger than the mammoths, and like them display the characteristically short neck, large tusks, as well as the elephantine conformation of the skull, all of which indicate the possession of a proboscis. The tusks are always large and strong, and do not appear to have been so much curved as in the true elephants. Some of the species present the peculiarity of having longitudinal bands of enamel, which traverse the entire length of the tusk and blend into a true sheath at the point. Some of the species display tusks in the lower jaw, which are generally insignificant in size as compared with those of the upper jaw. In the species under consideration there were two tusks in the temporary dentition in the lower jaw, neither of which appear, to have been replaced by permanent ones in the female, but of which one was succeeded by a permanent tooth in the male.

In time the genus *Mastodon* ranges from the Upper Miocene into the Post-Pliocene deposits inclusive. Its distribution in space is very extensive, having been found from the 60° of north latitude, it is claimed, throughout the greater part of South America. The habits of these creatures will doubtless ever remain shrouded in mystery, and in this as well as all other extinct animals we must depend upon analogical evidence for our opinions respecting them. It was believed by no less an authority than the immortal Cuvier that the food of the *Mastodon* consisted of tender vegetables, roots, and aquatic plants, in view of the tuberculous character of the teeth; the analogy of this is seen in the hogs and hippopotamus. This regimen would require more swamp-haunting and aquatic habits than the elephants possess, which indeed has been conjectured to be the case. Prof. Owen, on the other hand, suggests "that the large eminences on the grinding teeth, the unusual thickness of the enamel, and the almost entire absence of the softer cement from the grinding surface of the crown, would rather indicate that they had been instruments for crushing harder and coarser substances than those for the mastication of which the more complex but weaker grinders of the elephants are adapted."

RODENTIA.

With this order we enter a very natural group of smooth-brained, clawed *Mammalia*, which are either aquatic, arboreal or terrestrial in habit. The most natural primary grouping of the Monodelph mammals is best indicated by division into at least four branches. Beginning with the highest we would have, 1st, the series including the orders *Carnivora* and *Primates*, or the flesh-eaters, monkeys, apes and man, characterized by comparatively large and well-developed brains; 2d, the orders *Cetacea* and *Sirenia*, or whales, dolphins and seacows, characterized by the absence of hind limbs; 3d, the Ungulate or hoofed series, including the orders *Taxeopoda*, *Amblypoda*, *Proboscidea* and *Diplarthra*, which have just been considered; and 4th, the series embracing the orders *Cheiroptera*, *Bunotheria*, *Rodentia* and *Edentata*, or the bats, lemurs, insectivores, gnawers, ant-eaters, sloths and armadillos, characterized by having small, nearly smooth cerebral hemispheres, which leave the olfactory lobes and cerebellum uncovered, with claws or compressed ungues.

This latter series no doubt had a common origin with the ungulate division far back in the Eocene or Jurassic periods, and from which stem doubtless the existing Marsupials also sprung. From some of the earlier representatives of this series we can with little difficulty derive, (1) the *Carnivora*, through the *Creodonta*, a sub-division of the *Bunotheria*; (2) the *Cheiroptera*, through the insectivorous division; (3) monkeys and man, from the Prosimian sub-order of the same; and (4) lastly the *Edentata* and modern *Insectivora* have persisted with comparatively little modification. The *Pinnipedia* may represent an early off-shoot from the modern *Carnivora*, but taking into account the structure of the molar teeth as well as other points of osteology, they appear to have come off in the early Eocene from the *Creodonta*, when some of them possessed the simplified molars now exhibited by the seals. Prof. Huxley has endeavored to point out some affinities with the *Ursidæ* of the *Carnivora*, but the evidence which he adduces is scarcely sufficient to demonstrate such relationship.

As to the origin of the *Cetacea* and *Sirenia*, we know so little that it is useless to speculate. Upon this subject our ignorance is indeed dense, and how soon the light of paleontology will enlighten us the future will reveal.

This rude outline probably expresses the more important divergences that have taken place in the evolution of the *Mammalia*, and is strongly supported by the paleontological evidence at our command.*

The characters by which the *Rodentia* are separated from the two allied orders may be briefly stated as follows:

*See Vols. III and IV of the Hayden Geological Survey, final report, where this system is fully presented.

Teeth when present without any enamel covering. *Edentata.*

Teeth with enamel; mandibular condyle transverse; a post-glenoid process. *Bunotheria.*

Teeth with enamel coverings; mandibular condyle longitudinal; no post-glenoid process. *Rodentia.*

In point of numbers, as well as wealth in genera and species, the *Rodentia* are the most important of all the *Mammalia.* Notwithstanding the fact that they furnish the principal food supply for the more predaceous species, they continue to be the most numerous, and enjoy a wider geographical range than any other order of mammals, the loss which they sustain from carnivorous enemies, being compensated for by the rapidity with which they increase. Over 900 species are now known.

The principal modifications to be met with in the osseous system are seen in the skull and dentition. The premaxillaries are always large and exclude the nasals from contact with the maxillaries; the frontals are moderate and do not possess post-orbital processes except in squirrels, marmots, and hares; the zygomata are always present; the malar never sends up a process to meet the post-orbitals, and the orbital and temporal fossæ are always freely continuous. In the Porcupine division of the order, the infra-orbital foramen is enormously enlarged, almost equaling in size the orbital cavity; a portion of the masseter muscle passes through this opening. The palate is always very narrow, as compared with the width of the zygomata; and there are always well developed auditory bullæ.

In the dentition there are never more than two incisors in either jaw (except in the hares, which have four above), which grow from persistent pulps, and are always large, well curved, and strong; they are covered with enamel upon the outside only, an arrangement by which the tooth upon attrition continually preserves a chisel point. Canines are never developed, and there is a wide interval between the incisors and premolars. The normal number of true molars, 3, is present in all except the Australian Water Rats, in which they are reduced to two in each jaw; the premolars vary from $\frac{3}{2}$ in the hares and rabbits, to $\frac{0}{0}$ in other forms. The structure of the teeth in this order is subject to much variation, the most complex type being displayed by certain members of the Porcupine division, as the Capybara for example.

The primary division of the order is effected by arranging those that have only two incisors in the upper jaw, with fibula not articulating with calcaneum, and without an intertrochlear crest of humerus in one series; and those in which the incisors are $\frac{4}{2}$, fibula articulating with calcaneum, and an intertrochlear crest of humerus in another series. The first series includes three distinct divisions, the first of which is the *Hystricomorpha*, or the porcupines, and their allies; the second is the *Sciuromorpha*, or the

squirrels, marmots, and beavers; and third, the *Myomorpha*, including the mice and their allies. The second series includes but a single division, the *Lagomorpha*, or the rabbits, hares, and pikas.

The largest living representatives of the order are found among the *Hystricomorpha*, as the Capybara and Viscacha, for example, although the *Sciuromorpha* have a representative of considerable size in the beaver. The remains of an extinct rodent are found in the Post-Pliocene deposits of this country, which, without doubt, refer to a member of the *Sciuromorpha*, and which exceed in size any known rodent, living or extinct; this is

CASTOROIDES OHIOENSIS, Foster.

Plate 4, *figs*. 1, 2, 3.

This animal is indicated in the collection by an incisor tooth belonging apparently to the upper jaw. Its damaged condition, owing to the poor state of preservation, does not permit a satisfactory determination of this point. This species was first made known to science by Mr. J. W. Foster, one of the assistants in the Geological Survey of the State of Ohio, from an imperfect half of the lower jaw, an incisor tooth of the upper, together with a radius found in association with the remains of a *Mastodon*, in the State of Ohio, an account of which was published in Amer. Jour. Sci., vol. XXXI, p. 80. Subsequently an almost entire cranium was obtained from the State of New York, which was described and figured by the late Prof. Jefferies Wyman, in Boston Journal Natural History, vol. V, 1845–1847, pp. 385–401. Other fragments have been found from time to time in various parts of the United States, which indicate a wide range for the species.*

As the name implies, the bones resemble those of the beaver, *Castor canadensis*, to which family it has been referred. After a careful study of the remains, however, Mr. J. A. Allen has demonstrated the impossibility of referring it here on account of certain cranial and dental peculiarities. He has shown that it resembles the chinchillas and the beavers, but differs from both in important characters, on account of which he has proposed to establish a new family for its reception. He further adds: "The *Castoroides ohioensis* was about the size of a full grown black bear (*Ursus americanus*), hence somewhat exceeding in size the Capybara, the largest of existing rodents. A cast of a skull has a length of over twelve inches. The species being known from only a few cranial and dental remains, it is impossible to say much respecting its general form or probable habits. It may have been aquatic, like the beaver; but of this there is no evidence. The form of the occipital condyles and the surfaces for the attachment of the cranial muscles show that it differed greatly in habits from the beaver." The skull is represented in Plate 4.

*Bones and teeth have been found in Carroll, Kosciusko and Vanderburg counties, Ind.

EDENTATA.

This order has a moderate representation in the present epoch, there being upwards of forty species known, whose headquarters are in South America. The name, a most inappropriate one, signifies the absence of teeth, which is by no means true. It was, however, applied by Linnæus to signify the absence of teeth from the premaxillary bones, which is likewise not invariably the case; on this account the term *Bruta*, a scarcely less objectionable one, is not infrequently employed.

In the adult condition, the teeth are devoid of enamel; but Tomes has shown (Philos. Trans., 1876), that in one species at least (the nine-banded armadillo) there are enamel organs in the tooth germs, and he believes that all the species possess similar organs. This would seem to indicate that they represent, so far at least as their teeth are concerned, a, degeneration from a more normal condition. So little is known of their geologic history earlier than the Post-Pliocene period that it is at present a question impossible to decide.

The order is most naturally divided into two sub-orders, the *Phytophaga*, or vegetable feeders, and the *Entomophaga*, or insect eaters. Although the principal food of the latter group is insects, yet some of them will not refuse worms or carrion, as an article of diet. The distinctive characters of the *Phytophaga* are seen in the coalescence of the acromion with the coracoid process of the scapula; the absence of medullary cavities in the long bones; the union of the scaphoid and trapezial bones of the carpus; the anchylosis of the ischia with the anterior caudal vertebræ; and finally, in a vertical process from the lateral part of the zygomata of the skull.

In the *Entomophaga*, on the other hand, the acromion and coracoid are never united; the long bones have medullary cavities; the scaphoid and trapezium remain distinct; the ischia are normal, and there is never any descending process from the lateral part of the zygomata, although in a few instances the anterior part of the arch sends down a prolongation. This group includes the "Ardvark" or Cape Ant-eater, the Pangolins or Scaly Ant-eater, the Ant-eaters proper, the Armadillos and the extinct Glyptodont forms from South America.

The *Phytophaga* embraces the sloths and a number of extinct sloth-like forms, mostly of gigantic size. The sloths proper are grouped in a separate family (*Bradypodidæ*), which includes two genera, the two and the three-toed sloths (*Cholæpus* and *Bradypus*), remarkable animals, confined to the dense forests of South America, where they lead a purely arboreal life, suspended by their long hook-like claws to the branches of the trees. The extinct forms of this division, of which seven genera at least are known, are included in the family *Megatheriidæ*. They vary in size from

that of an adult grizzly bear to proportions scarcely less than that of an elephant. The three genera best known are *Megatherium*, *Mylodon* and *Megalonyx*. This latter genus is indicated in the collection by the greater part of the skeleton of an adult individual, including the skull, which were obtained by Dr. David Dale Owen* on the banks of the Ohio River, some five or six miles below Henderson, on the Kentucky side. These remains formed a part of the collection of the bones of extinct animals which Dr. Owen submitted to Prof. Leidy's inspection in 1853, and their description was incorporated in his admirable "Memoir on the Extinct Sloth Tribe of North America," published in the Smithsonian Contributions to Knowledge in the same year. The anatomical description of these remains, given by Dr. Leidy, has been so thoroughly done that nothing remains to be said concerning this part of the subject. A figure of the skull is given in Plate 5.

MEGALONYX JEFFERSONI, Harl.

Plate 5, *figs.* 1 *and* 2.

This species, which is familiar to naturalists as *Megalonyx jeffersoni*, was first brought to the attention of the scientific world by the illustrious Thomas Jefferson, in a communication read before the American Philosophical Society of Philadelphia, as early as 1797, entitled "A Memoir on the Discovery of Certain Bones of a Quadruped of the Clawed Kind in the Western Parts of Virginia." The fragmentary remains upon which this memoir was based, consist of several claws, a femur, ulna and radius, together with several other bones belonging to the feet. The shape and form of the claws led Mr. Jefferson to regard them as having belonged to a gigantic carnivorous animal. Dr. Wistar and, later, Cuvier, upon the acquisition of more perfect material, subsequently demonstrated the affinity of the extinct animal with the existing sloths. Since that time, numerous remains of this genus have been found in cave deposits throughout the eastern and southern parts of the United States, and more recently in the sand-beds of Oregon, supposed to be of Pliocene age. Several species are known.

Owing to the great bulk of these animals, it is impossible to suppose that they were arboreal in habit; but, judging from the construction of their feet, adapted, as they were, for terrestrial locomotion, and provided with strong and powerful claws, it has been suggested that they were accustomed to stand upon their hind legs with the assistance of a large tail, and draw the branches within reach of the mouth. It is usually in this position that they are represented.

Since the descendants of this group are so exclusively arboreal, it has been further suggested that, by some probable decrease in size, the boughs no longer yielding to the accommodation of the animal, the sloth eventually yielded and went aloft among the branches.

* In cabinet of State University, Bloomington, Indiana. COLLETT.

The size of *Megalonyx jeffersoni* was about equal to that of a full grown ox.

In conclusion, we trust that we may be pardoned if we indulge the imagination in its retrospective reaches, and endeavor to picture to the mind a landscape containing a grouping of the more prominent animals, as they doubtless appeared, on the banks of the beautiful Ohio, in the misty twilight of long ago. Huge Mammoths and Mastodons would have been seen loitering near the water's edge, or lazily browsing on the neighboring trees; herds of Horses, giant Bisons, and Elk grazed upon the adjoining hills, while numerous smaller species of ruminants would be seen in their appropriate places; the Tapir, Peccary, and Peccary-like Platygonus, would have been found in the dense growths of the swamps and marshes; the mighty Sloths and Castoroides would also contribute to the scene; while, lurking in the back-ground, the stealthy Lion and wary Wolf waited to pounce upon their unfortunate victims. Whether this scene was ever beheld with human eyes, is a matter which yet lingers in the shadows of uncertainty, but it is probable that man was there in all the nakedness of his primitive barbarity.

APPENDIX.

GENUS EQUUS.

The following attempt at a discrimination of the species of Equus* known to me, or so fully described as to be well known, must necessarily be regarded as provisional, until the skeletons are more fully recovered. American extinct species only are introduced:

I. Long diameter of anterior internal lobe of superior molars not greater than one-third the long diameter of the crown.

Borders of lobes crenate; internal anterior lobe notched on the inner side so as to be bilobate; crowns a little curved; large . . . . *E. crenidens*, Cope.

II. Long diameter of anterior internal lobe more than one-third and not more than one-half the anteroposterior diameter of the crown.

α Crowns more or less curved.

Crowns wider than, or as wide as long; enamel edges little folded . . . *E. curvidens*, Owen.

$\alpha\alpha$ Crowns straight, or nearly so.

β Diastemata longer.

*See Owen's Philosophical Transactions, 1869, for figures of the dentition of these species.

Crowns nearly square; enamel not very complex; no facial fossa; maxillary bone produced much beyond M. iii . . . . *E. caballus*, L.

$\beta\beta$ Diastemata shorter.

γ No facial fossa.

Crowns nearly square; enamel not very complex; maxillary bone little produced behind last molar; smaller. . . . .

E. fraternus; E. hemionus; E. burchelli; E. quagga; E. zebra; E. asinus, L.

Crowns longer than wide on face; enamel little complicated; face and maxillary unknown; large . . . . . . *E. occidentalis*, Leidy.

Crowns square; enamel more folded than in other species; face and maxillary unknown; large . . . . *E. major*, Dekay.

γ A facial fossa.

Crowns nearly square; enamel less complex; maxillary short posteriorly; smaller . . . . *E. andium*, Wagner.

III. Long diameter of anterior inner lobe more than half that of crown of molar teeth.

Crowns square; enamel little complex (in Mexican specimens); diastemata and maxillary behind shorter; no facial fossa; large. . .
E. excelsus, Leidy.

Crowns square; enamel little complex; smallest species . . . .
E. barcenæi, Cope.

In using the above table it must be noted that gradations in the diameter of the anterior internal column (or lobe) exist, not only between individuals of the same species, but between different teeth in the same jaw. This diameter is always greatest in the last superior molar, and the characters of this tooth are such that they can not be used in connection with the above table.*

As already remarked (p. 6), two species of horses have left their remains in the Post-Pliocene and Pliocene beds of Indiana—the *E. fraternus*, Leidy, and *E. major*, Dekay. The former is generally rather smaller than the latter, and is not yet distinguishable by its teeth from the *Equus asinus* and its immediate allies. From the absence of specimens of crania, its affinity to the *E. caballus* is not yet traceable. It is probable, however, that it is like the *E. tau*, Owen, of the valley of Mexico, of which crania are known, and it may be even identical with that species. (In this case the name *E. tau* becomes a synonym.) In that case the species belongs to the *E. asinus* division. It will then follow that the evidence for the existence of the *Equus caballus* in North America prior to the advent of Europeans will be much weakened, since it is on teeth of the *E. fraternus* that such a possibility has been predicated. Many of the teeth referred to the *E. fraternus*, are, as observed by Leidy, not distinguishable specifically from those of the *E. caballus*. *E. D. Cope.*

*See Proceedings American Philosophical Society, 1884, p. 10, for a discussion of the American extinct horses.

PLATES AND THEIR EXPLANATIONS.

PLATE 1.

Page 20.

Under view of the cranium of *Platygonus compressus*, Le C., from a Saltpetre cave in Kentucky; after Leidy.

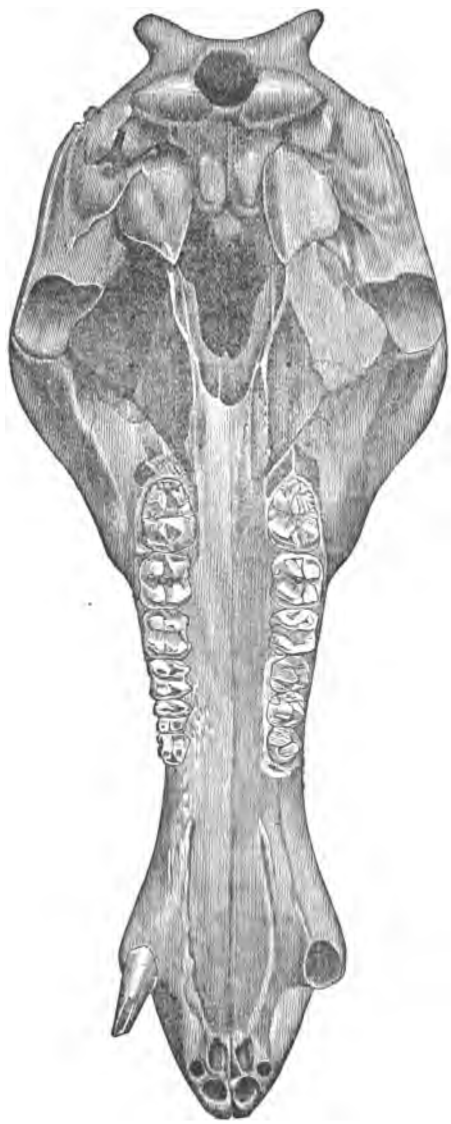


PLATE 2.

Page 22.

Fig. 1. Left maxillary bone of *Cariacus dolichopsis*, Cope, with teeth, from below.

Fig. 2. Left mandibular ramus of *Cariacus dolichopsis*, Cope, external view; *a* from above, *b* from behind. Figs. 1 and 2*a* natural size.

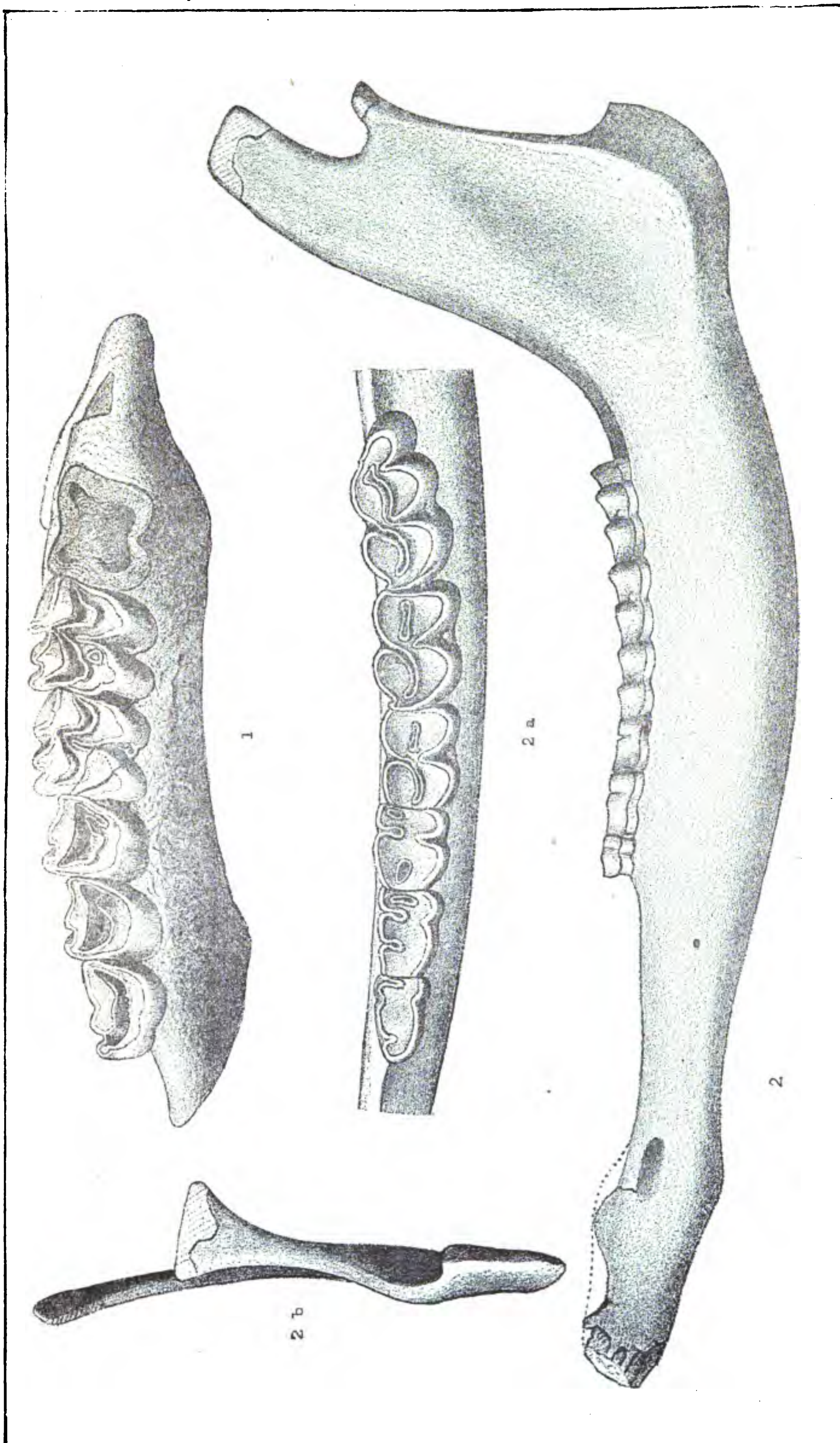
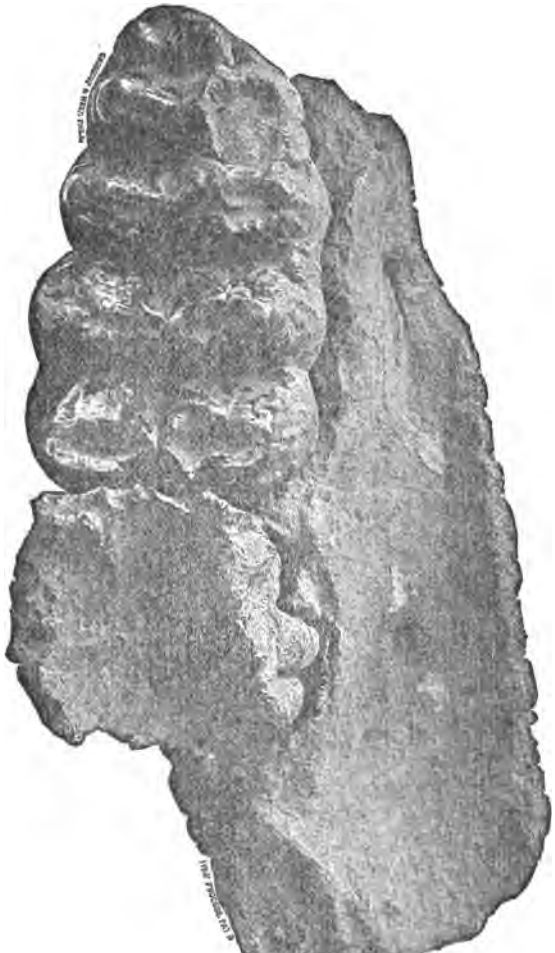

1
2 a
2
2 b

PLATE 3.

Page 33.

Fig. 1. Portion of left superior maxillary bone of *Mastodon americanus*, Cuv. About one-third natural size.

Fig. 2. Tooth of *Mastodon americanus*, one-fourth natural size; side view.



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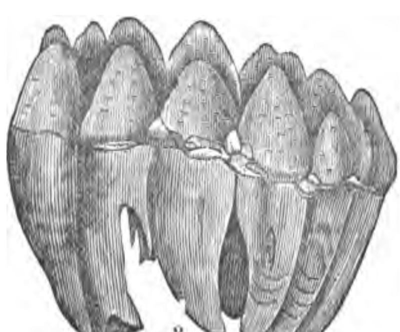

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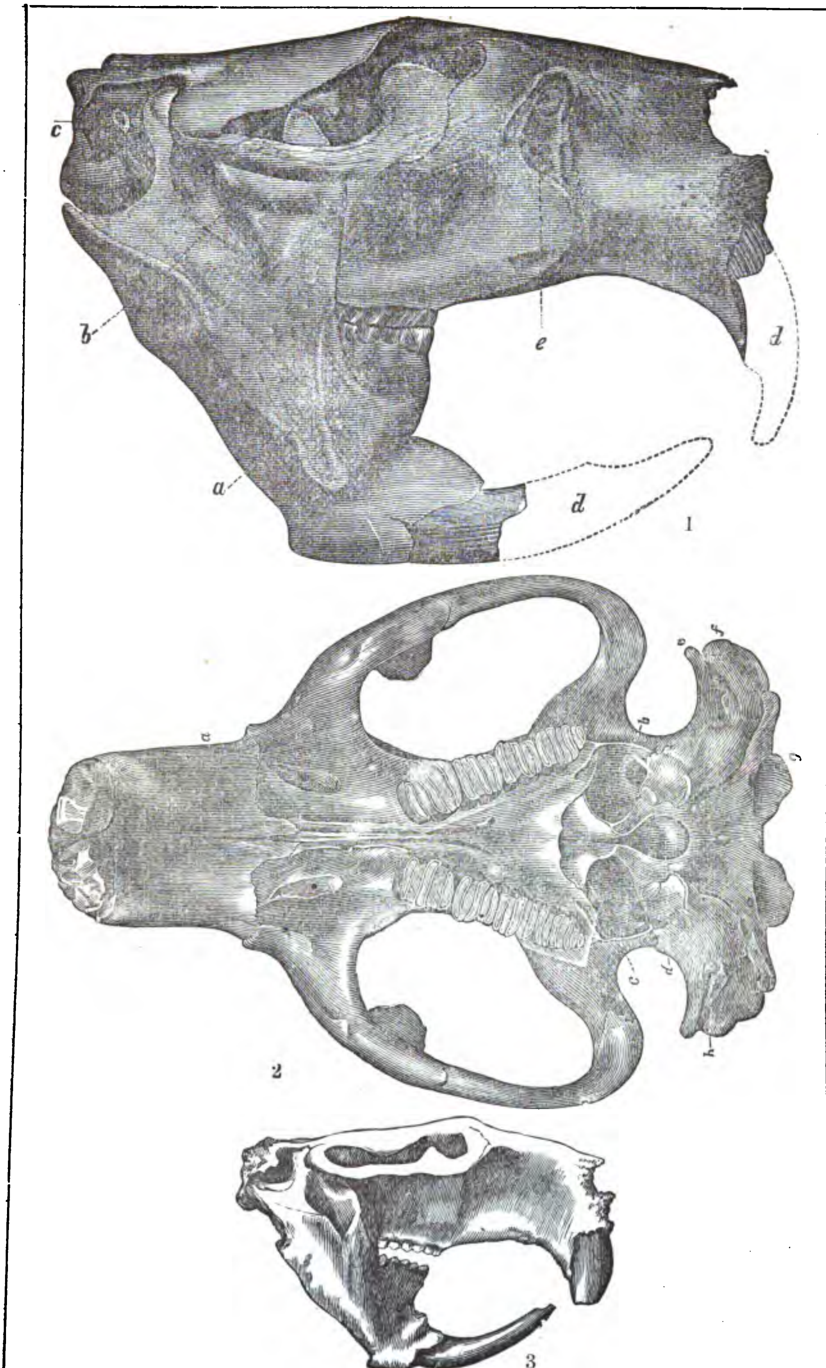
PLATE 4.

Page 37.

Fig. 1. Skull of *Castoroides ohioensis*, Fost. Two-fifths natural size. *a*. Inferior attachment of masseter muscle. *b*. Deep fossa below sigmoid notch of mandible. *c*. External auditory meatus. *d*. Superior and inferior incisors. *e*. Foramen infra-orbital.

Fig. 2. Under view of same, two-fifths natural size. *a*. Incisive foramina. *b*. Pterygoid fossa. *c*. Internal pterygoid plates. *d*. Fossa in base, occipital. *e*. External auditory meatus. *f*. Mastoid process. *g*. Condyles. *h*. Tympanic bulla. After Hall and Wyman.

Fig. 3. Reduced figure, showing length of incisors.


c
b
a
e
d
d
1
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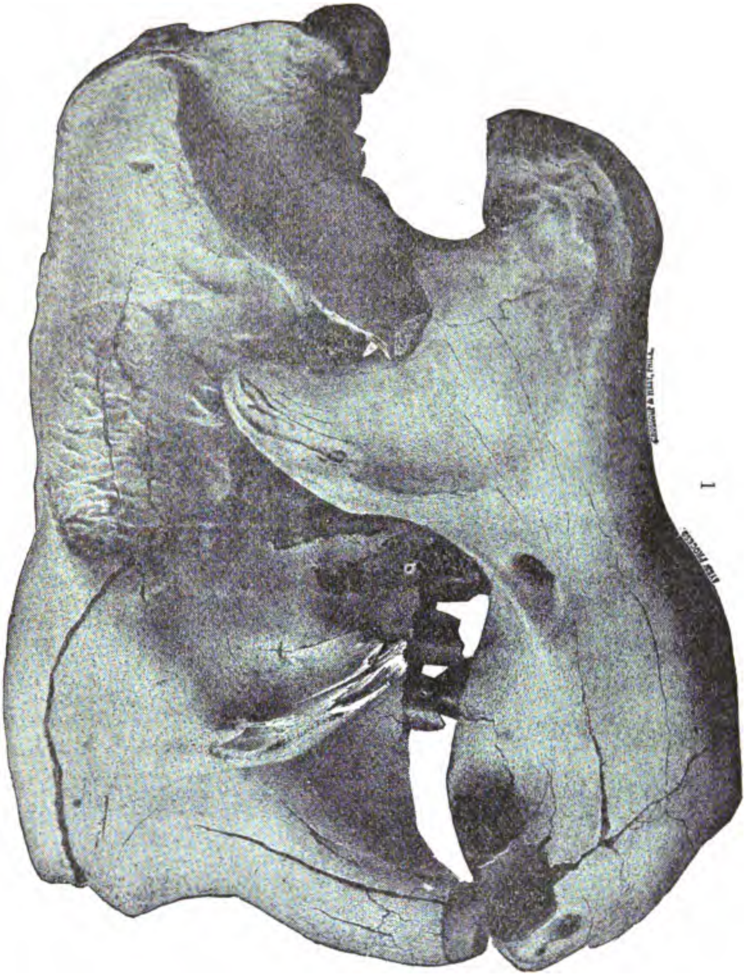
3

PLATE 5.

Page 39.

Fig. 1. Skull of *Megalonyx jeffersoni*, slightly more than one-third natural size; in cabinet of Indiana State University, from Kentucky, on the banks of Ohio river, below Henderson; after Leidy.

Fig. 2. Claw-phalange of same, one-half natural size (very poor).



1

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PLATE 6.

Pages 32, 33.

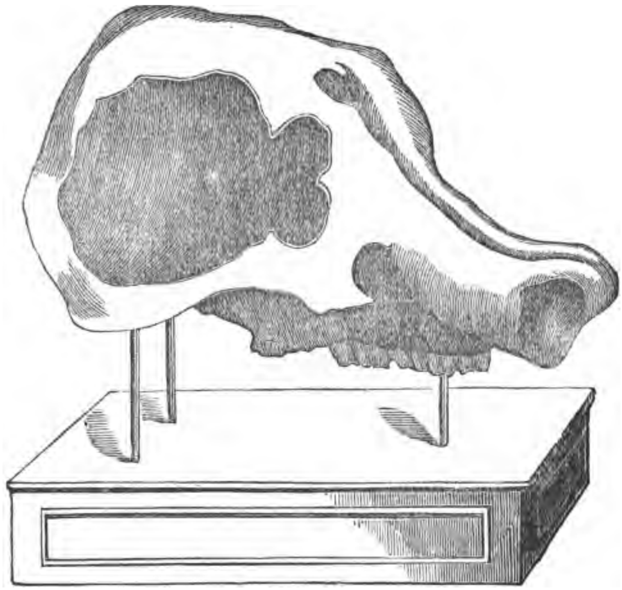
Fig. 1. *Mastodon americanus.* Skull one-eleventh natural size.

Fig. 2. *Elephas primigenius.* Lower jaw, young, one-fourteenth natural size.

Fig. 3. One-eighth size view of molar, *E. primigenius.*

Fig. 4. Quarter size view of molar of *E. primigenius.*

Fig. 5. Face view, or grinding surface, of molar of Indiana Elephant; one-fourth to one-fifth natural size.



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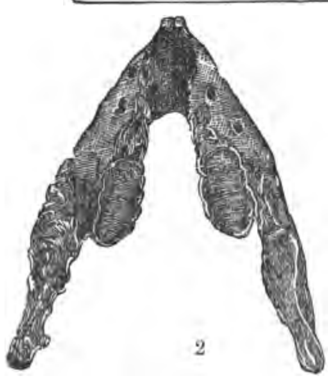

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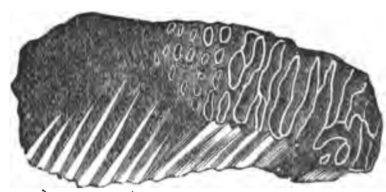

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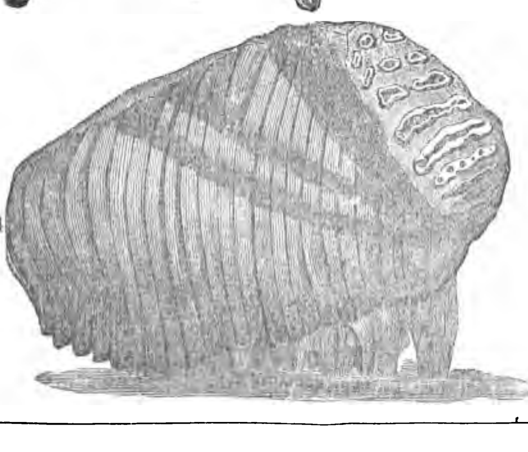

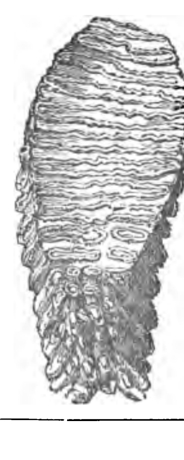

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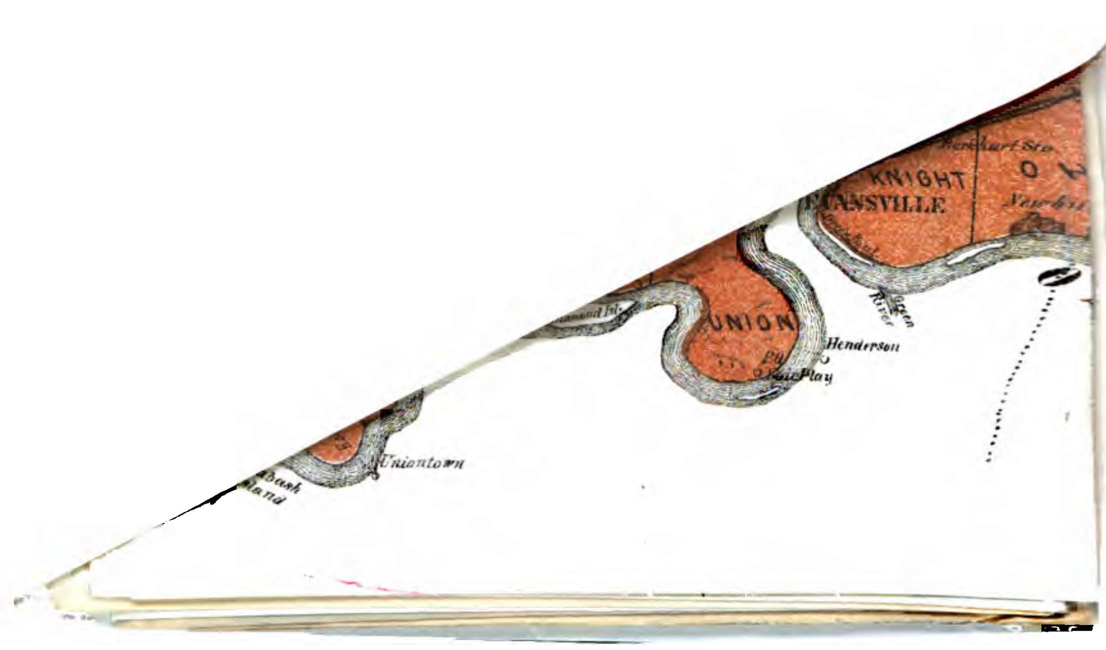
INDEX.

PART SECOND.

POST-PLIOCENE VERTEBRATES OF INDIANA.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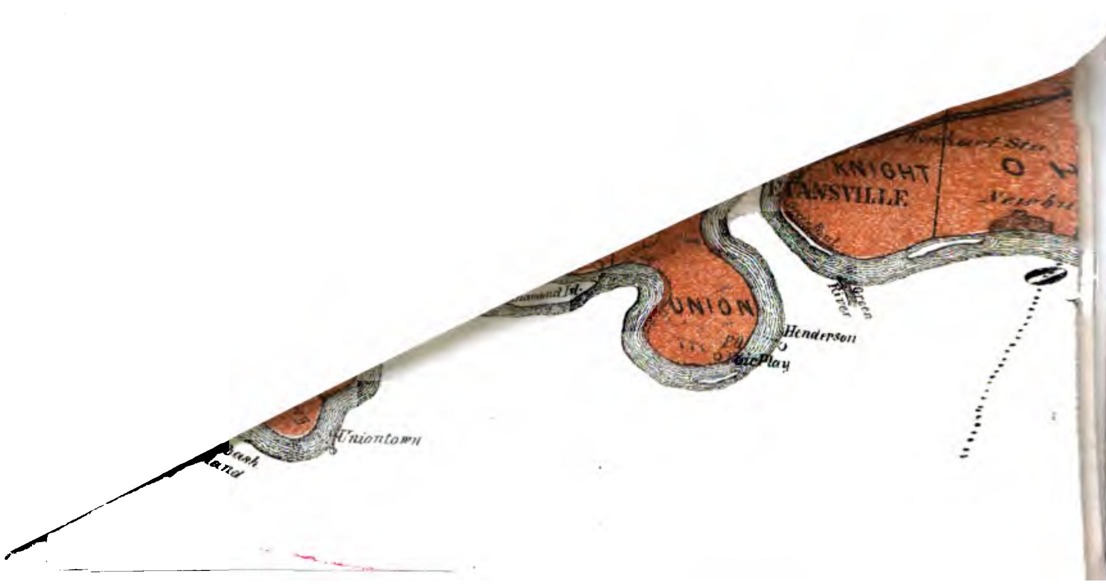
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